By Charles Williams

1845

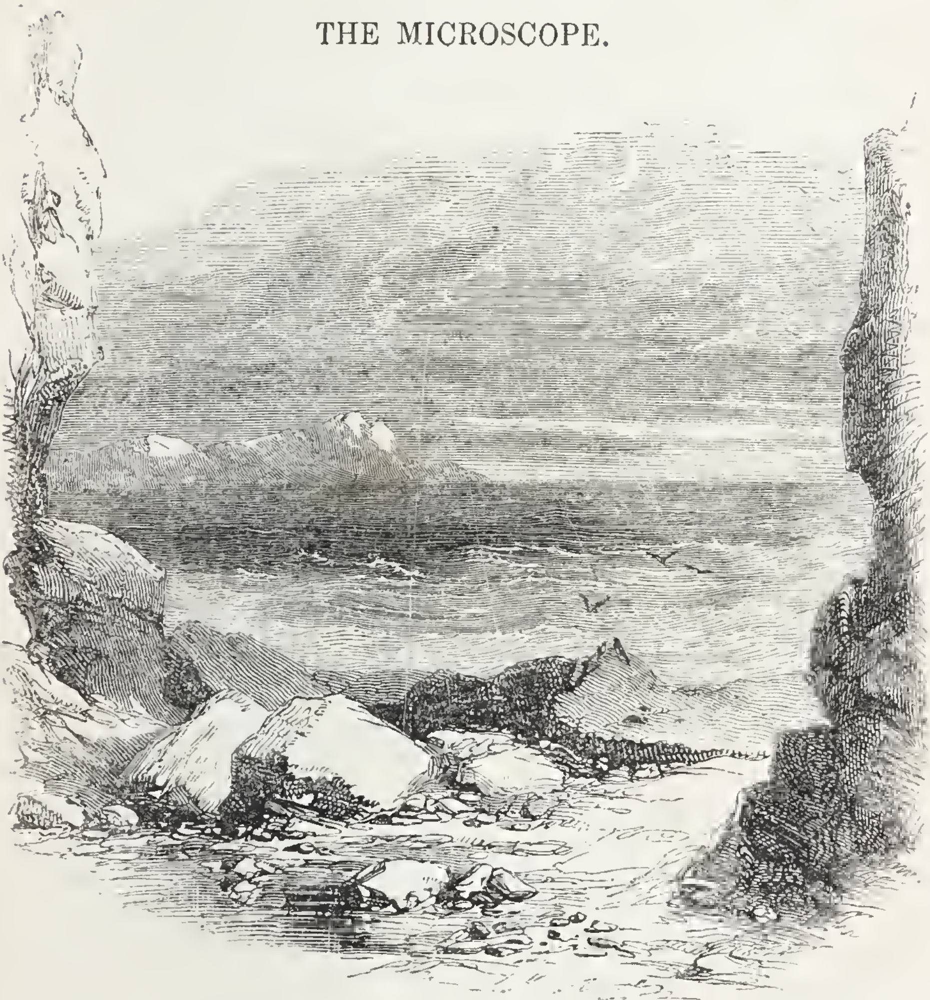
CURIOSITIES

OF

ANIMAL LIFE;

WITH

THE RECENT DISCOVERIES OF
THE MICROSCOPE.



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PREFACE.

The object of the writer is to unfold a few pages of the extensive and interesting volume of Natural History, relating to those comparatively simple, but wonderful forms of life, of which little, as yet, is known. And as the results of scientific observation are often repulsive to the general reader, from the form in which they are given and from their numerous technicalities, he has aimed to render them popular and attractive.

The inspired truth that "the works of the Lord are great, sought out of all them that have pleasure therein," exerts far too little influence. God has "magnified his word above all his name," but, as

Dr. Chalmers has remarked, "It is a most Christian exercise to extract a sentiment of piety from the works and appearances of nature."

Under this conviction, the reader is now invited to the devout contemplation of—

> "Things curious,
> Yet unfamiliar;"

while in Milton's words it may be said:—

> "Thy desire which tends to know
> The works of God thereby to glorify
> The great Workmaster, leads to no excess
> That reaches blame, but rather merits praise
> The more it seems excess; * * *
> For wonderful indeed are all His works,
> Pleasant to know, and worthiest to be all
> Had in remembrance always with delight."

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CURIOSITIES

OF

ANIMAL LIFE.

CHAPTER I.

INTEREST OF THE SCIENCE OF NATURAL HISTORY.

THAT the science of Natural History is invested with great interest, is a fact universally admitted. Objections to its study have sometimes arisen from the neglect of naturalists to ascribe all its wonders to the great First Cause. It is hoped that no such charge will be alleged against the present volume. Its aim is to illustrate the power, wisdom, and goodness of our Heavenly Father; and to give to God the honour due to his name.

It may be well to premise, that the attention of the reader will be directed successively to the Microscope, with its recent improvements, so important an auxiliary to diligent and careful investigation; to Life, and its Phenomena; to the Distinction between Animals and Vegetables; and then, from the simplest forms of organic existence, to the Wheel Animalcules.

The descriptions given of this series of animated beings will be those of the best authorities at the present time, confirmed, in many instances, by personal observation; and the feeling they are designed to produce, is that so well indicated in the words of old Samuel Purchas :—

"Nicocastrus, an Ælian, finding a curious piece of wood, and being wondered at by one, and asked what pleasure he could take to stand as he did still gazing on it, answered, 'Hadst thou mine eyes, my friend, thou wouldst not wonder, but rather be ravished, as I am, at the inimitable art of this rare and admirable piece. I am sure no picture can express so much wonder and excellency; but we want Nicocastrus' eyes to behold it.'

"And the praise of God's wisdom and power lies asleep and dead in every creature, until men actuate and enliven it. I cannot, therefore, altogether conceive it unworthy of the greatest mortals to contemplate the miracles of Nature; and that, as they are the most visible in the smallest, and almost contemptible creatures; for then most lively do they express the infinite power and wisdom of the Great Creator, and direct and draw the minds of the most intelligent to the first and prime Cause of all things, teaching them, as the power, so the presence of the Deity, in the smallest creatures."

As Baxter remarks ;—

"It is God appearing in the creatures, that is the life, and beauty, and excellence, and use of the

creatures. Without him they are but carcases,—deformed, useless, vain, insignificant and very nothings."

Let us then adopt the language of the psalmist:—

> "Great is the Lord, and greatly to be praised;
> And his greatness is unsearchable.
> One generation shall praise thy works to another,
> And shall declare thy mighty acts."—PSALM cxlv. 3, 4.

And well will it be for every servant of the Most High to add to the utterance of these words, the devout resolution of their inspired author:—

> "I will speak of the glorious honour of thy majesty,
> And of thy wondrous works."—VERSE 5.

For the truly Christian mind, the task on which we have now entered must have a peculiar and transcendent interest. Nothing is more clear on the page of revelation, than that the Saviour, in whose atoning blood and perfect righteousness he implicitly trusts, whom, though unseen, he supremely loves, and whose example he is constantly concerned to imitate, is the Creator of the universe. In the love which so condescendingly and graciously bends towards us, we discern his infinite majesty; in the eye which melted over our woe, his infinite knowledge; and in the arm which brought salvation, his almighty power.

> "Lo, this is our God;
> We have waited for him, and he will save us."—ISA. xxv. 9.

If, therefore, all things that are in heaven and in earth were created by the Lord Jesus, he must have

a right to the most unqualified property in them. As he is "Head over all things," he demands the highest love of all his intelligent and rational creatures.

> "Whom have I in heaven but thee;
> And there is none upon earth that I desire beside thee," *

should therefore be the language of every heart. And well is it when the study of any part of His works affords to his disciples a stimulus to gratitude and confidence; while a sense of the necessity of a more full revelation than that of nature, leads others to the belief of the gospel, through the operation of the Holy Spirit, and to an entire reliance on that Saviour, who, because he was "obedient unto death, even the death of the cross," is "highly exalted," and has "a name which is above every name."†

* Psalm lxxiii. 25. † Philippians ii. 8, 9.

CHAPTER II.

THE MICROSCOPE.

A LARGE amount of valuable information would have been acquired in reference to natural objects, had they been surveyed only by the unassisted eye. Scientific research would obviously have been aided by the simple magnifying glasses so commonly used; but at length an instrument was obtained surpassing all others. Its name, Microscope, is derived from two Greek words meaning "to see small things." Its early history is involved in obscurity; and we can only glance at a few striking facts illustrative of its invention, and indicative of the still more wondrous results of its further improvement.

It is remarkable that Seneca should state, that "letters, although minute and obscure, appear larger and more clear through a glass vessel full of water;" and yet that no valuable application should have been made of the discovery by the ancients. A single microscope may be easily obtained by piercing a small circular hole in a slip of metal, and introducing into it a drop of water, which will assume a spherical form on each side of the plate;

but no trace of it appears in the history of many ages.

Claims to its actual invention have been preferred in behalf of more than one individual. In a work published in 1665, the writer assigns the credit of it to Jansen, the reputed contriver of the telescope. Among the testimonies he adduces, is a letter from William Boreel, envoy from the States of Holland, who had frequently been in the shop of Jansen. He had often heard that the microscope was invented by that person, or by him in connexion with some members of his family; and being in England in 1619, he saw in the hands of his friend Cornelius Drebell, an instrument six feet in length, consisting of a tube of gilt copper, supported by thin brass pillars in the shape of dolphins, on a base of ebony, and adapted to hold any objects to be examined; which Jansen had presented to prince Maurice, and Albert archduke of Austria. No account, however, is given of the internal structure of this microscope.

Fontana, a Neapolitan, formed a microscope in 1618, of two double convex lenses—that is, each one having two spherical surfaces, as represented in the annexed diagram, L L—and wrote an account of it in a work which appeared some years afterwards. It seems, therefore, that a microscope of some kind was invented by Jansen, and that the honour of this one in particular is due to Fontana.

The structure of a lens, (a name derived from the Latin for a small bean,) must immediately have led

to the discovery of what is popularly termed its magnifying power, but in reference to which many errors prevail. The following diagrams will aid the reader.

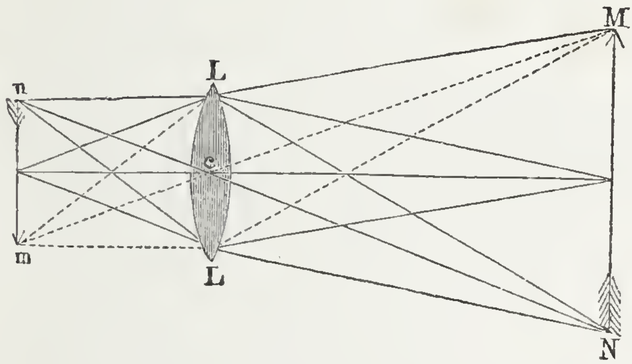


Fig. 1.

M N is an object placed before a convex lens L L, every point of which will send forth rays in every direction. Those rays which fall upon the lens will be refracted to foci behind the lens. Since the focus where any point of the object is represented in its image is in the straight line drawn from that point of the object through the middle point c of the lens, the upper end M of the object will be represented somewhere in the line M c m, and the lower end N somewhere in the line N c n, that is, at the points m, n, where the rays L m, L m, L n, L n, cross the lines M c m, N c n. Hence m will represent the upper, and n the lower end of the object M N. It is also evident, that in the two triangles M c N, m c n, m n, the length of the image, must be to M N, the length of the object, as c m, the distance of the image, is to c M, the distance of the object from the lens.

In order to explain the power of lenses in magnifying objects and bringing them near us—or rather, in giving magnified images of objects, and bringing the images near us—we must examine the different circumstances under which the same object appears when placed at different distances from the eye. If an eye placed at E looks at a man c b, fig. 2, placed at a distance, his general outline only will be seen, and neither his age, nor his features, nor his dress will be recognised. When he is brought gradually nearer us, we discover the separate parts of his dress, till at the distance of a few feet we perceive his features; and when brought still nearer, we can count his very eyelashes, and observe the minutest lines upon his skin. At the distance E b, the man is seen under the angle b E c; and at the

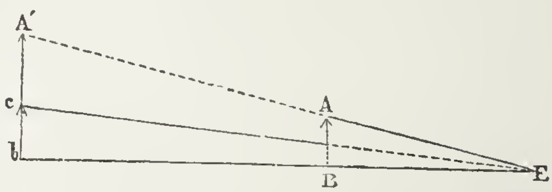


Fig. 2.

distance E B he is seen under the greater angle B E A or b E A′; and his *apparent* magnitudes, c b, A′ b, are measured in those different positions by the angles b E c, b E A, or b E A′. The apparent magnitude of the smallest object may therefore be equal to the apparent magnitude of the greatest. The head of a pin, for example, may be brought so near the eye that it will appear to cover a whole

mountain, or even the whole visible surface of the earth; and in this case the apparent magnitude of the pin's head is said to be equal to the apparent magnitude of the mountain, etc.

Let us now suppose the man c b, to be placed at the distance of 100 feet from the eye at E, and that we place a convex glass of 25 feet focal distance half way between the object c b and the eye, that is, 50 feet from each; then, as we have previously shown, an inverted image of the man will be formed 50 feet behind the lens, and of the very same size as the object, that is, six feet high. If this object is looked at by the eye, placed six or eight inches behind it, it will be seen exceedingly distinct, and nearly as well as if the man had been brought nearer from the distance of 100 feet to the distance of six inches, at which we can examine minutely the details of his personal appearance. Now, in this case, the man, though not actually magnified, has been apparently magnified, because his apparent magnitude is greatly increased, in the proportion nearly of 6 inches to 100 feet, or of 200 to 1.

But if, instead of a lens of 25 feet focal length, we make use of a lens of a shorter focus, and place it in such a position between the eye and the man, that its conjugate foci may be at the distance of 20 and 80 feet from the lens—that is, that the man is 20 feet before the lens, and his image 80 feet behind it—then the size of the image is *four* times that of the

object, and the eye placed six inches behind this magnified image will see it with the greatest distinctness. Now in this case the image is magnified four times directly by the lens, and 200 times by being brought 200 times nearer the eye; so that its apparent magnitude will be 800 times larger than before.*

Not thirty years ago, it was asserted by men of no less eminence than Dr. Wollaston and M. Biot, that the compound microscope would never rival the single one; and for this conclusion there appeared to be weighty reasons. And yet existing difficulties, which pressed heavily on their minds, have all been surmounted. More than one name is entitled to honour in this service; especially the late Mr. Tulley, of London, who was induced by Dr. Goring to attempt the construction of an achromatic† object glass for a compound microscope.

The white light which comes from the sun, or any other luminous body, is composed of seven different kinds of light—red, orange, yellow, green, blue, indigo, and violet. Mr. Tulley, therefore, produced a glass composed of three lenses, which gave to the vision a distinctness not previously attained, by combining the colours of which light is composed, and causing objects to be seen in white light. Great importance was once attached to

* Brewster on Optics, pp. 45—48.

† An optical term derived from the Greek, and signifying "without colour."

glasses of considerable size, but now achromatic lenses vary from two inches to a twelfth or sixteenth of an inch focal length. The Microscopical Society of London was expressly formed to render this instrument still more available for scientific research.

Wherever we turn—whether we search our own dwellings, the meadow or the moorland, the hill or the forest, the ruin crumbling into dust, or the sea-shore,—whether we examine the waters of springs, rivers, lakes, or oceans, or the fluid contents of the living internal tissues,—there may be discovered plants and animals, alike unknown to our unaided vision, yet endowed with organs perfectly adapted to their respective necessities, and, with regard to the latter, to their full and high enjoyment. Even in the aqueous vapours, and dust of the atmosphere, are germs of living beings, which the microscope can alone present to our interested and delighted contemplation. Of this the succeeding pages of this volume will afford ample evidence.

CHAPTER III.

THE PHENOMENA OF LIFE.

THE natural objects by which we are surrounded, to an extent at which we have just rapidly glanced, are arranged, almost intuitively, under two great classes—the Inorganic and the Organic ; the living and the lifeless. The question, therefore, immediately arises, What is life ? What is that, the effects of which appeal so forcibly and constantly to our senses, as to render the distinction just made one of our most familiar ideas—the first and almost unconscious result of our earliest observations ?

Life cannot be considered abstractedly, but only in the phenomena of organic bodies. Its full investigation is strictly within the province of the physiologist ; and great and absolute results, constituting the essential characteristics of animated beings, depend on laws imperfectly understood, or absolutely beyond the research of human industry ; but all that can be effected by diligent observation and just reasoning, is solemnly incumbent on the reflective Christian mind. If "the works of the Lord are great," neglect, indifference, or a slight and passing attention, must be proportionately culpable.

In the study of organic bodies, the first thing that strikes us is the vital union of their constituent

particles, which is totally unlike every other combination of matter. If, for example, we merely place an acid and an alkali together in a glass, the particles will remain in juxtaposition, and yet in perfect quietude, because they are only *mechanically* combined. But water poured on the mass becomes the means of a *chemical* union, which is strikingly apparent in immediate effervescence. In like manner, a combination of nitre, sulphur, and charcoal, is familiar to us as gunpowder—the particles of these substances being mixed *mechanically;* but no sooner does a spark fall on the train, than the affinities between these substances produce so intimate a union, that we are astounded, perhaps, by the result. Still, as there is a marked distinction between a mechanical and a chemical union, there is one far more palpable between inorganic and organic bodies, as the consequence of *vital* force.

In crystals, or any other inorganic bodies, it may also be remarked, we observe a determinate and settled form; but in those which are organic, a perpetual change is carried on by the agency of vital power. Thus, particles which were lately incorporated, are thrown off, and others, foreign and inorganic, are taken up to be incorporated and thrown off, in their turn. Life maintains its triumph over the laws of dead matter, preserving for its appointed time the identity of the plant or the animal, until vitality ceases, and its operations give place to the laws of chemical affinity, which being unopposed,

exert their full influence. Death is, in fact, the conquest of the vital forces by the physical.

Another fact demanding attention is, that every animated being is the product of an antecedent, called its parent, which it essentially resembles, as like produces like, according to a law unknown to inorganic matter. The lily does not aspire to the magnitude of the cedar, or the lamb to the stature of the giraffe. Life springs from life, which has been transmitted through an unbroken chain of being, since the fiat of the Creator, whose exclusive prerogative it is to call any creature into existence. But the offspring, whether of the plant or animal, is not produced at once, with all its parts and powers developed in full maturity; on the contrary, its first state is that of a germ, often astonishingly minute, and most marvellously prepared, according to its circumstances, by the great Author of life, for its subsequent and complete development.

Were we asked, What is that microscopic object which we cannot but regard as the most simple and wonderful? we should answer, A vesicle, or cell. The cell is the elementary organ of organic bodies. This statement requires illustration; but it may be abundantly given from all the circumstances in which life can be traced.

One of the simplest forms of vegetation may be observed, for example, in yeast. Let a small portion of it be examined at intervals, under the microscope, and it will prove to be one congeries

of cells. But if, after an interval, we resume our examination, each of these little vesicles will be seen putting forth one or more prolongations or buds, which in time become new vesicles, like their parents; these perform the same process, and the multiplication goes on, so that within a few hours, each single vesicle has developed itself into a row of four, five, or six.

THE YEAST PLANT.

Another process may sometimes be witnessed; for the vesicles burst, and discharge a number of small grains, all of which form themselves into new cells. In due time, on ordinary occasions, the brewer comes in to stop the marvellous process of vegetation which has been going on, of which probably he has not the slightest idea; but it will prove, on examination, to be, when five or six vesicles are formed in each group. At this crisis, the groups separate into individuals, resembling those which first formed the yeast, and thus the brewer actually takes out more than he put into the fluid.

BUDDINGS OF THE YEAST PLANT.

MULTIPLIED CELLS FROM BUDS.

The most simple or elementary texture of vegetation is a somewhat similar structure to that which exists in animals. The first trace of the latter that can be observed consists of a very soft and pulpy substance, which, at this early period, is loaded with fluid. In its nature, it is homogeneous, presenting neither interstices nor fibres; and it may be drawn out into glutinous filaments. In this substance cells are afterwards formed, and developed into the various tissues of the body.

And how amazingly minute are these tissues! The white glistening threads traversing fibrous membranes, may be discerned by the naked eye; but so far from being single, they are actually bundles of fibres, requiring a microscopic power to distinguish any one of them. It is probable that those forming the areolar tissue are the most minute; they are said to vary from $\frac{1}{3230}$ to $\frac{1}{1430}$ of a line in diameter—a line being one-twelfth of an inch; their edges are quite smooth, they are transparent, and appear to be composed of gelatine. Not only do they form bundles, and thus constitute larger fibres, but arranged side by side they become the most delicate membranes.

The entire body of most of the species of animals placed at the bottom of the scale is composed of a simple arrangement of cells closely packed together, the walls adhering. After a time these walls which adhere together may become absorbed, and we may be able to prove that the tissue was originally

formed from cells only by an examination of a young animal of the species.

But although the higher animals are at an early age composed entirely of simple cells, yet when arrived at maturity they are composed of certain tissues such as bone, muscle, nerve, cartilage, tendon, etc., which are united together by the areolar or binding tissue, of which mention has already been made. Recent researches have shown that all these tissues are formed from cells by a gradual process of development.

Areolar tissue appears designed to unite the various constituent parts of the body, and to keep them in place, by the contractile force with which it is marvellously endowed; to facilitate their movements by means of its lubricating fluid, thus preventing the injurious effects of friction and concussion; and to furnish an appropriate structure for their reception. It has been also supposed that, being a bad conductor of heat, it tends to preserve the uniform temperature of the body. How many purposes are thus secured by the all-wise God, by means of this exquisitely simple substance!

On minutely examining the internal organization of every living body, we discover a union of solids and fluids; the solid parts consisting of minute particles, so arranged as to form fibres and tissues of various density and structure. Everywhere these solids are pervaded by a circulating fluid, from which the particles composing them are elaborated, and by

means of which the organic system is nourished. When we attempt to investigate the intimate texture of the solids beyond a certain point, we are foiled; no eye can scan, no instrument can follow, the mysteries of organic structure, or its circulating fluids.

As vitality is essential to the circulation of the fluids of the system, so it is by the same power that certain tubes are enabled to absorb particles of extraneous matter, carry them into the mass of circulating fluid, and become incorporated with the body. On the other hand, the system throws off by transpiration, particles which, having been integral portions of itself, are now useless; and hence it may with truth be said, that no living body is, after a certain period, the same, particle for particle, as it was, though its identity remains. From this view we shall be readily led to conclude, that a due proportion of aliment is required, in order that the loss be counterbalanced; and that when this is withheld, the body becomes emaciated, till at last the vital energies yield, and no longer sustain the organic structure. But in order to the growth of an organic body, the accession of particles must preponderate over the loss; and hence, from birth to maturity, there is not only a rapid circulation of the vital fluid through the system, deposited everywhere from its stores, but a rapid reception and assimilation of extraneous matter. and, accordingly, an unceasing demand for aliment.

There is, it may be observed, a remarkable attraction through an animal or vegetable membrane, of a thin fluid by one that is denser. Thus, Dutrochet found that if he filled the swimming bladder of a carp with thin syrup, and placed it in water, the bladder gained weight by attracting water through its sides. To this he gave the name of *Endosmose*, from two Greek words, from the principal current *flowing inwards.* He also found that the water in which he had placed the bladder contained sugar, or in other words, that at the same time a large quantity of water was passing into the bladder, a small quantity of the syrup was passing out. This lesser and *outward* current he denominated *Exosmose.*

Then again he discovered that if the same bladder were filled with water and placed in a thin syrup it lost weight; a large amount of the water passing out and a smaller quantity of the syrup passing in. In both these instances it is seen that the principal current was from the less to the more dense fluid. The same result occurred in the transmission of fluids through the tissue of plants. It was found possible to gorge parts of vegetables with fluid by merely placing them in water, and to empty them again by rendering the fluid in which they were placed more dense than that which they contained. Dutrochet says, that water thickened with sugar, in the proportion of 1 sugar to 2 water, produced a power capable of sustaining a column of

mercury of 127 inches, or the weight of $4\frac{1}{2}$ atmospheres.

The forces thus apparent are, however, dependent on life. They are not exerted by the roots of dead plants. The wick of a lamp sucks up oil only when it is lighted, so that the fluid already absorbed is in some degree removed, and thus capillary attraction supplies what is lost by combustion. Just so, as the plant exhales from the leaves, the *endosmose* will keep up the supply; but, let vitality be destroyed, and absorption will cease.

Organic bodies grow, therefore, not by the action upon them of external agents, but by rendering these subservient to their purpose. The primary and leading feature of vitality is indeed the process of nutrition; and it can only be exemplified by an organic being. Its first operations appear in the alteration of the medium by which it is surrounded. Oxygen is the great supporter of life; it is indispensable to the performance of every vital operation; deprived of it, organic existence ceases, or is incapable of developing into activity.

In vain, however, do we ask, What is life? If we apply to chemistry, what do we learn from its researches? Only that the elements of organic bodies are carbon, oxygen, hydrogen, azote, and alkaline and earthy salts. Chemistry, potent over the vast empire of inert matter, is unable to ascertain what life is. Within its own dominions it can

analyze and combine; make solids fluid, and fluids solid; resolve things into their elementary gases and recombine them; ascertain the necessary proportions in which two or more bodies unite, whence shall result a product totally differing from each component in character and properties: all this and more is within its power; but it cannot recompose a single fluid, nor a single solid of any organic body. Here its penetration is baffled, and its art at fault. If, then, chemistry cannot ascertain the true nature of the constituents of organic bodies, neither can it discover the means by which they maintain their specific differences, not only as it regards the form, but the quality of their substance; quality, which widely differs even where the same nutriment is in each instance received. The same soil, the same water, the same air, may nourish the vine and the aconite, the rose and the hemlock, the nutritious plant and the deadly poison; their very roots and leaves may be intertwined; but their identity and their specific properties will continue unaltered.

It is evident, however, that the great Creator has endowed organic nature with a remarkable property, which the tubes of all having life possess, and upon which their action depends, termed by physiologists—irritability. It denotes a power residing in the fibrous parts of organic bodies, of responding to the action of various and appropriate stimuli, external or internal; and exhibited in

contractile or expansive movements. It renders the tubes or vessels agents in the propulsion of the circulating fluid. It is diplayed by the sensitive plant, when its leaves, on being touched, collapse; by the sunflower, when it bends to the refreshing light; and by the night-folded blossom, expanding with the return of day.

In animals, we see this property residing to a wonderful degree in the fibres of the muscles, whether the muscles be of the class termed involuntary, such as the heart of a mixed character, such as those of respiration; or purely voluntary, as those of locomotion. Many consider the irritability of muscular fibres as depending immediately upon the influence of the nerves with which they are supplied, and not as an independent faculty. Now, that volition acts as a stimulus to the voluntary muscles through the medium of the nerves, is obvious, for we can move a limb at pleasure. That the agitation of the nervous system, from whatever cause, influences the action of the voluntary muscles, and even those of volition, is also manifest. Yet in all this there is nothing to contradict the opinion, that irritability is an independent property of muscular fibre, since it is not annihilated by the cutting off of all communication between the nerves and the brain, or the spinal marrow, which are their great centres. If, for instance, the heart of a frog be removed from the body, it continues to act for a considerable period, and even after action has apparently ceased, its

contraction will be repeated on the application of stimuli. The same fact may be observed, also, in the heads of recently slaughtered animals; the muscles of the ox, for example, when skinned and hung up, may be seen contracting and relaxing, their movements vigorously responding to the application of stimuli.

The growth or development of living beings, for which such wondrously minute and exquisite arrangements have been made by the great Creator, is determinate. At the appointed time, maturity is reached and a change is easily discoverable: the demands of the system for nutrition are less pressing; assimilation is not so rapid; the circulating fluids are propelled feebly; and all the phenomena of life are languidly carried on. This decline, the harbinger of death, proceeds from the gradual exhaustion of the vital energy—an exhaustion for which we cannot account. We call it, indeed, a law of nature; but why should not the organic machine, having once begun, go on for ever? Why should not the powers which conducted it to maturity and enabled it to make good its losses and injuries still continue in all their mysterious energy? Who can tell why?

"It appears," says Cuvier, "that life ceases from causes similar to those which interrupt all other known motions, and that the hardening of the fibres, and the obstruction of the vessels, would render death a necessary consequence of life, as rest is that

of every movement not occurring in a vacuum, when that event shall not be forestalled by a multitude of extrinsic causes." There is something, however, beyond this rigidity of the fibres, this obstruction of the vessels. These must be themselves the effects of an antecedent cause, and will not bear to be compared with the phenomena produced by chemical agents. In short, the bounds of the duration of living beings are prescribed by laws as certain, but as mysterious, as those which determine form or regulate growth. With the cessation of the vital principle, every phenomenon which distinguished between organic and inorganic matter, ceases also. The outward form, indeed, may remain for a shorter or more protracted period; but it is now no longer under the influence of the laws of life. Its component particles are the subjects of another empire; they form new combinations, and become lost and mingled with the elements around.

To such a transition, inorganic matter presents no analogy. However it may be increased or diminished, or, whatever may be its mutations, every change it displays is the result of extraneous agencies, and dependent on the laws of chemistry and mechanics. But here there is no vital bond; death is a necessary consummation of life, the goal to which it inevitably tends, the irrevocable destiny of organic existence.

As to the dissolution of our race, there is no

mystery. "By one man sin entered into the world, and death by sin; and so death passed upon all men, for that all have sinned." "Thanks be unto God for his unspeakable gift." Through the great Apostle and High Priest of our profession, Christ Jesus, "life and immortality" are brought "to light through the gospel." And happy are they, who, receiving his testimony, "set to their seal that God is true," and exclaim, in the enjoyment of "things present," Death and things to come are *ours!*

In leaving this part of our subject, we feel that what life is, even in its humblest forms, must remain inscrutable. Here, as in numerous natural objects, a barrier is placed which we cannot pass. The sphere of man is bounded, his researches are limited, and the hidden mysteries around and within him, are far too deep for him to fathom. Let us then take our proper station. To deny, as some do, what is unseen, or not fully within their grasp, although attested by ample evidence, is, at once, their greatest folly, and most awful crime. It is for us to be humble: the only attitude that becomes us, is that of reverent and devout disciples. In the highest and noblest efforts of man, we may detect the weakness and infirmity of his fallen nature; but in the works of God we have a revelation of his character, a mirror in which we may behold his infinite perfections. Let it then be our concern, amidst our ignorance and errors, gratefully to appeal to him who

knows all things. The phenomena of life—those evidences of a mysterious and inscrutable principle—are all arranged by him; of that principle he is the source; he alone understands in what that "inconceivable something" consists; on his will it depends, and in his hands are the issues of life and death.

CHAPTER IV.

ORGANIC NATURE DIVIDED INTO ANIMALS AND VEGETABLES.

It has already been apparent that natural objects comprise the inorganic and organic, and it is now to be shown that the latter class is subdivided into animals and vegetables.

Animals have ordinarily been briefly characterized as living, sentient, and capable of motion; and vegetables as merely endowed with life. But in order to arrive at more clear and definite ideas, let us examine particularly the difference that is manifest.

Vegetables are for the most part fixed in the earth, by the root, while another part is raised into the air, and consists of the stem, the branches, and the leaves. In the disposition of these portions, we look in vain for rigorously symmetrical arrangement; there is, indeed, order, harmony, and a due adjustment of parts: one vegetable is the type of its species, one leaf the type of every leaf on the same plant, and consequently of the leaves of every plant of the same species; but this is all. The elm, for example, has its peculiar leaf, bark, and adjustment of branches, so that it cannot be mistaken for the oak; but one elm, though a type of the species, does not present the same number of branches or

leaves, nor the same proportions between one part and another. Moreover, the vegetable, fixed to the earth, is incapable of removing to another locality, nor does it possess the power of voluntary motion. It is therefore incapable of avoiding injuries; but with this incapacity of self-protection, it is as insensible to pain as it is to pleasure. A sentient being, that is, one susceptible of pleasure and pain, must be capable of voluntary action, and endowed with the power of locomotion.

A near approximation to animal existence appears in a plant commonly known as Venus's Fly-trap,

VENUS'S FLY-TRAP.—DIONÆA MUSCIPULA.

which inhabits the southern part of the United States of America. Certain of the leaves are fringed

at their sides with a row of long spines, and have the power of folding their two sides towards each other, so as to inclose the insects which settle on their surface. On each half of the blade of a leaf, three thorns are placed, and when any one of them is slightly touched, the action of the trap is complete. So perfectly do the spines cross each other, that the captured prey cannot possibly escape; and, indeed, the more it struggles, the greater is the pressure it experiences. In the engraving, the structure and action of the leaves are clearly shown. The victims thus made have appeared to some to supply the plant with needed and beneficial nutriment, probably nitrogen from animal matter. However, recent investigations tend to show that this curious action is not connected with the nutrition of the plant, and, although in it there is presented some resemblance to the functions of animal existence, in reality the process is of a different nature. Still, notwithstanding the analogy which is presented by this curious plant to animal functions, its action is not voluntary, like that of a sentient being, and it must continue rooted in the earth.

If now we consider the animal, we find it composed of parts symmetrically arranged, and constituting a body possessed of certain definite members. Fixed by no root to one spot, in which to live and perish, it is free; it moves, it feels, it exerts the power of locomotion. Such are the obvious differences between animals and plants; but if we pro-

ceed to a closer investigation of their respective organization, we shall discover yet wider lines of distinction.

In all animals, we find an internal apparatus for the reception of food which there undergoes the process of digestion. From the inner surface of the stomach arise a multitude of minute tubes, termed by anatomists, *lacteals*, which take up such particles as are digested, and ultimately convey them into the circulating fluid, where they lose all traces of their former appearance, and become incorporated with the body. Now, the very existence of such an apparatus, for the preparation of food previously to its admission into the system, supposes a complication of organs, both internal and external: internal, as to the accomplishment of the change necessary to be wrought on what is subjected to their action: external, as to the powers of searching for food, and its acquisition when found.

No common internal cavity for the reception and precursory digestion of food is discoverable in plants: it is received into their system at once; the fibres of their roots resembling the absorbing tubes which arise from the inner suface of the stomachs of animals. The food of plants is already prepared, and is already in a state of solution; it consists of various materials present in soil and in the atmosphere. The food of animals on the other hand is taken in for the most part as solid matter, which has to undergo a process of solution or digestion

before it can be absorbed into the system. Where the seed germinates, there the plant finds its nutriment; and if this be accidentally denied, there must the germ prematurely perish. The Creator has fixed the plant, and has also placed its nutriment in external contact with it; he has made the animal locomotive, and has consequently given it an internal apparatus for the reception of a supply of matter, whence the system may be duly nourished and sustained till more can be acquired.

When, however, we say that animals are locomotive, we do not forget that there are some, low in the scale of being, which are destitute of this faculty; but, in such instances, we find a plant-like simplicity of structure, and a plant-like arrangement of external organs. Even in these, there is an internal digestive apparatus, simple, it is true, while the animal seeks its food; if it cannot quit its local station, it spreads abroad its arms or feelers in search of what the teeming waters of the river or the sea may bring, to be received internally and digested. There is, then, between the polyp and the plant a clear, yet narrow line of demarcation.

It is equally worthy of remark, that the plant possesses no true sensation, as animals do, and that the power of locomotion is necessarily connected with the faculty of sensation. That a being, susceptible of pleasure and pain, endowed with various senses, and having affections and passions should, statue-like, be fixed motionless upon a life-enduring

pedestal, would be an outrage upon the harmony and laws of nature: where such endowments exist, the power is also given of seeking the good and avoiding the evil.

The leading differences between animals and plants may therefore be summed up, by observing, that all animals possess an internal cavity for the reception and digestion of food; that, with some exceptions, they have organs of locomotion, symmetrically disposed; that they are endowed with sensation or feeling; that the greater number have additional senses, as of sight, hearing, taste, and smell, a condition connected with a high degree of organization and nervous development; and that in such as are thus gifted, there are exhibited various instincts, and a diversity of affections and passions.

We might detail the chemical differences which have been discovered in the elementary structure of animals and of plants; but to what do these differences amount? Plants, we are told, as it respects their solid parts, contain carbon, oxygen, hydrogen, with scarcely a trace of azote, and that silica is sometimes incorporated with their outward covering. The solid parts of animals consist of lime or magnesia, united with carbonic or phosphoric acids; but if we compare the beings of the animal kingdom, destitute of solid parts, as the *medusæ*,* with mucilaginous vegetables, we shall find that the gum or

* The round masses of jelly so often observed on the sea-shore.

mucilage of the plant afford no azote, but that azote, on the contrary, enters largely into the composition of the albumen, or gelatine, of the soft animal. In some plants it is acknowledged that substances of an animal nature, or abounding in azote, have been detected; not, however, constituting a whole plant, but only occurring in certain situations, and always in company with other substances of a decidedly vegetable nature, or consisting entirely of carbon, hydrogen, and oxygen. But in the soft animals there is no extensive combination of carbon, oxygen, and hydrogen, into which azote does not enter. Such, then, are the elementary or ultimate principles which make up the compounds of animal organization; these compounds being gelatine, albumen, osmazone or extractive mucus, sugar, oils, such as spermaceti, fat, and blubber, and various acids, as *uric*, *lactic*, *benzoic*, and many others. Of these chemical elements are constituted the solids and fluids of the animal frame.

The conclusion thus gained, has not, however, satisfied that intense thirst for knowledge, to which we owe some of the most remarkable and valuable attainments of the human mind. The microscope has been plied minutely, accurately, and perseveringly, to examine the tissues or component structures of animals and vegetables, and with some degree of success. We shall soon have evidence that the Corallines are chiefly animals; but some of these, admitted by Cuvier into the same series, have

been demonstrated, by the employment of high magnifying powers, to be actually vegetables. In some instances, the microscope reveals a broad distinction between an animal and a vegetable tissue, but in others, it is diminished until any difference is scarcely, if at all, perceptible. A further study of the different tissues of organic bodies will doubtless add important facts to the knowledge already acquired.

Nor should it be overlooked, that "it has been recently stated, and apparently upon good foundation," as Professor T. R. Jones remarks, "that there are organized forms, that are vegetables at one period of their existence, and animals at another. Many of the *confervæ*," consisting of simple tubular jointed species inhabiting fresh water, "for example, are equally claimed by zoologists and botanists; and some among them are said to be possessed of locomotion in one stage of their growth, while in another they are fixed and motionless. So nearly, then, do the animal and vegetable worlds approximate, remote and separate as they appear to be when examined only in their typical forms. Light and darkness are distinct from each other, and no one possessed of eyesight would be in danger of confounding night with day; yet he who looking upon the evening sky would attempt to point out precisely the line of separation between the parting day and the approaching night, would have a difficult task to perform. Thus it is with the physiologist

who endeavours to draw the boundary between these two grand kingdoms of nature; for so gradually and imperceptibly do their confines blend, that it is at present utterly out of his power to define exactly where vegetable existence ceases, and animal life begins."

The difficulty, thus apparent, of drawing a precise line of demarcation between animals and vegetables has led Dr. Carus to observe that, "it seems to follow that we are entitled to suppose between plants and animals an original organic kingdom; nay, that this is the only way in which we can succeed in laying down a truly generic series of these singular organizations, beginning with the most simple, and losing itself in one direction in the vegetable, and in the other, in the animal kingdom."

CHAPTER V.

THE SPONGE.—THE HYDRA.

THE animals accounted lowest in the scale of existence, are by no means the least wonderful of the works of the Creator. Indeed, in some respects, they excite more than common interest, as discovering to the reflective mind the utmost simplicity of organization, conjoined with animal, not vegetable life. Their structure is surpassed in intricacy by that of many vegetables, perhaps by most; yet, simple as it is, it is only the first of a series of gradations, which conducts us to the highest orders of animated nature.

Naturalists place a group or assemblage of animals* lowest in the scale, in which no distinct nerves are to be perceived. They are, with few exceptions, tenants of the water. They consist essentially of a gelatinous substance, the solid constituents of which bear but a trifling proportion to the fluid. This gelatine is sometimes unsupported by any kind of framework; but generally it either invests, or is contained in a horny or a calcareous support, which is elaborated from it, and varies greatly in outward form and appearance.

Though no nervous fibres have been detected, it

* Acrita.

is most probable that nervous matter, in the form of a subtle fluid, or of atoms hitherto beyond detection, may be blended with the gelatine. True blood vessels do not exist; yet in some groups canals are excavated in the substance of the gelatine, through which absorbed fluids circulate, and are carried to a central cavity. This apparatus fulfils at once the double office of aërating the system, (for oxygen, as we have seen, is indispensable to animal life,) and of supplying it with nutriment; which it cannot be doubted is absorbed and assimilated. In some of the simplest animals, indeed, a more perfect set of alimentary and aërating organs is present, and their use cannot be mistaken. The power of locomotion enjoyed by these beings differs exceedingly; and many, fixed like plants, live and die on one spot. None have true limbs, but many have tentacles, arms, or feelers, by means of which they secure their prey.

To give an example: all are familiar with the lightness, softness, and elasticity of sponge. It exhibits generally the same structure, having numerous pores and circular holes, which lead into canals permeating the whole substance. It imbibes with great facility a large quantity of water, or indeed any fluid, which is held in the meshes of its rude and singular network, until, being forced out by pressure, it acquires its former bulk.

The name of sponge is derived from the Greek word to squeeze, and shows that it was early noticed

for its peculiar qualities. Thus, Homer describes Vulcan obeying the charge of Thetis:—

> "First from his forge dislodged, he thrust apart
> His bellows, and his tools collecting all,
> Bestow'd them careful in a silver chest;
> Then all around with a wet sponge he wiped
> His visage, and his arms, and brawny neck."

The ancients used it also as a soft and elastic lining for their heavy brazen helmets, and we employ it for various purposes.

The extent and importance of the sponge fisheries of the Mediterranean and Red Sea attracted attention to it in remote antiquity. Great doubt was felt, however, as to its true character. Aristotle described it as a stationary or rooted animal, but it is probable, from other statements, that he considered its place to be intermediate between the animal and vegetable kingdoms. Pliny, who in his account of sponges is greatly indebted to the Stagyrite, places them among the productions which have a third or middle nature, and are neither living creatures nor plants.

Nor can we be surprised at the hesitation so long manifest. Who that takes up a piece of common sponge, but would consider it as a kind of vegetable? Even if told that when first procured, it was covered with a gelatinous film, he might reply, with some degree of force, "So are many species of seaweed;" and he might add, "Where is its sensibility, and its motion; it does not betray

even the irritability of the sensitive plant, the sunflower, or the daisy, that folds at eventide; it is rooted to one spot, it has no definite alimentary canal, and it cannot even select its food." And this is true; so closely, indeed, does the animal kingdom trench on the vegetable; so nearly, at one point, do they approximate.

It was long before opinion on this subject became absolutely settled. Even Ray and Linnæus placed sponges among marine vegetables, and we are indebted for more correct knowledge to John Ellis, a merchant of London, who devoted his leisure to natural history. After entertaining some doubts on the subject, he formed the mature opinion that the sponge is an animal, through the pores and canals of which the water circulates. His labours were rewarded, in 1768, by the Copley medal of the Royal Society; and his belief is that of most naturalists and physiologists at the present time: among whom Dr. Grant is entitled to special mention, for his minute and elaborate examination of the structure and habits of this remarkable creature.

The crumb of bread sponge is well described by the name it bears, not only as it appears to the eye, but as it feels to the touch. Another sponge* is not uncommon in clear rivulets, adhering to stones: its colour varies from bright green to pale brown, and changes according to the action of light. From this circumstance, it has been supposed that these

* Spongia fluviatilis.

fresh-water sponges are really within the pale of the vegetable kingdom. But a different conclusion has been arrived at, we think most justly, in reference to the sponges that are marine. Many inhabit the shores of the ocean between tide marks, preferring a site near the low ebb, where, however, they are daily covered with the water, and alternately left exposed to the atmosphere. Others, of a fibrous or fleshy texture, are the inhabitants of deeper water, and are never left uncovered. When, however, they are exposed, from their locality, to an unusually great agitation of the sea, they are said to have a structure proportionally dense and compact. In the intertropical latitudes they display gigantic forms, and strange or grotesque figures; in the colder latitudes, they are smaller, and of firmer and more rigid texture. They often grow in places which the returning tide leaves dry; but their congenial abode is in sheltered and tranquil spots, in caves and fissures of rocks, where the water, never ruffled by the storm, is "deeply, darkly, beautifully, blue." Fixed, plant-like, to the rock, they festoon the deep sea caves; they line the walls of submarine grottoes, and hang as grotesque ornaments from the roof; some, like inverted goblets, aptly termed "Neptune's drinking cups;" some, like fans, some, like globes, and others, like intertwined branches of uncouth growth.

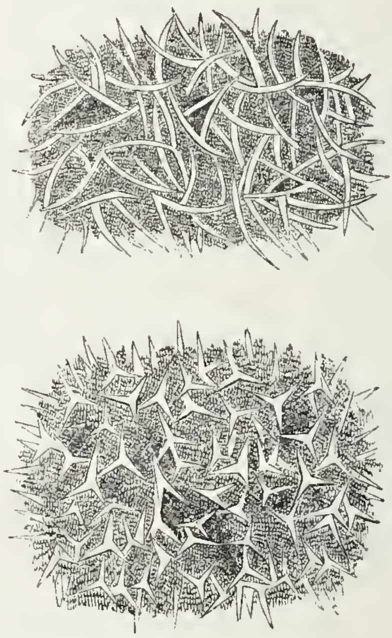
In the Mediterranean Sea, about the islands of the Archipelago, sponge is found adhering to the rocks,

from which they are not detached without considerable effort. In several of the Greek islands, the inhabitants have been trained from their infancy to dive for sponges. The extraordinary clearness of the water facilitates their operations. At the Cyclades, sponge-diving forms the chief employment of the population. The sea is at all times beautifully clear, and the experienced divers are capable of distinguishing from the surface the points to which the sponge is attached below, when an unpractised eye could but dimly discern the bottom. Each boat is furnished with a large stone attached to a rope, and this the diver seizes in his hand, on plunging head foremost from the stern. He does this in order to increase the velocity of his descent; thus economizing his stock of breath, as well as to facilitate his ascent when exhausted at the bottom, being then quickly hauled up by his companions. Few men can remain longer than about two minutes below; and as the process of detaching the sponge is very tedious, three, and sometimes four divers descend successively to secure a particularly fine specimen.

The canals and pores of a living sponge are filled with a fluid resembling the white of an egg, varying in quantity according to the species. When a drop of it is examined under a microscope, it appears entirely composed of very minute transparent grains, either spherical or ovate, nearly all of the same size, with some moisture. The fibrous

structure of the sponge, with which we are all familiar, is the framework, or under skeleton of the living animal; the characters presented by it greatly differing in the various species, which are extremely numerous.

In the common sponge the fibres are elastic and horny in their texture, and when highly magnified, appear to be tubular. In other species, the framework consists of a firm inflexible tissue, of inter-



SPONGES.

The upper figure represents one with horny fibres; the under figure, one with silicious spicula.

crossing filaments, also tubular, and the living gelatine exhibits bands of a more cartilaginous consistency than ordinary, and is also more or less

replete with minute crystallized spicula. The spicula are usually simple needle-like points, but sometimes they are three or four pointed.

Multitudes of spicula are placed longitudinally around the internal canals, of which they form the walls; they may be obtained by washing a sponge, of which the animal matter is decomposing, or by fusing it before the blow-pipe; they are mostly found to consist of silica or flint, and minute as they are, are capable of scratching glass.

A small portion of silica has been detected in the ashes of the common sponge, as one of the constituents in the composition of its elastic fibres. It appears, moreover, that the proportion of silica increases according to the firmness of the fibres of sponge, and that where these are elastic, animal matter predominates. The forms of the spicula are constant in every species, and consequently become tests in their identification. In some species, the spicula are calcareous; and whether calcareous or silicious, they assume the forms which the crystals of lime and silica present under ordinary circumstances.

Though every species of sponge has its characteristic figure, still no two individuals of the same species agree in external form, or in the number and precise directions of their large canals. Among the higher animals, every species resembles the rest of its species in the form of the limbs and teeth; in the length and figure of the ears, tail, muzzle, etc., and also in the arrangement and co-

louring of the hairs, spines, scales, or feathers. But this definiteness of figure, involving a constancy in the number and arrangement of composing parts, diminishes in degree as we verge towards the lower groups, and when we arrive at the lowest, we see diversity in the midst of sameness.

Nor can we be surprised at this, when we reflect upon the condition of the nervous system, and upon the vital laws by which these beings are governed. No two sponges of the same species correspond in figure, or in the number of their canals; for the latter multiply as the animal increases, and circumstances influence development in one part more than another.

But though this be the case, there are limits to the law of variation, so that no species puts on the appearance of another. The cup sponges never approach such as are branched, nor these such as resemble tufts of moss; though two cup-sponges are never precisely of the same outline, nor two branched sponges of the same shape, and with the same figure and proportion of their ramifications.

Dr. Grant put a small branch of a sponge, with some sea-water, into a watch-glass under the microscope, and on reflecting the light of a candle through the fluid, he perceived that there was some inward motion in the opaque particles floating through the water. On moving the watch-glass, so as to bring one of the apertures of the sponge fully into view, he beheld for the first time, he says, "the

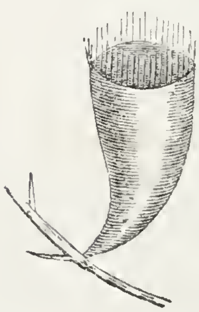
splendid spectacle of this living fountain, giving forth, from a circular cavity, an impetuous torrent of liquid matter, and hurling along in rapid succession opaque masses, which it strewed everywhere around. The beauty and novelty of such a scene in the animal kingdom long arrested my attention, but

ACTION OF A LIVING SPONGE.
The water appears discharged downwards.

after twenty-five minutes of constant observation, I was obliged to withdraw my eye, from fatigue, without having seen the torrent, for one instant, change its direction or diminish in the slightest degree the rapidity of its course. I continued to watch the same orifice, at short intervals, for five hours, and sometimes observing it for a quarter of

an hour at a time, but still the stream rolled on with a constant and equal velocity." These currents take place only from those parts that are under water, and immediately cease when the same parts are uncovered, or when the animal dies. Placed as the sponge is, lowest in the scale of animated beings, in no one respect has it been neglected by the all-wise and beneficent Creator, whose care of it is as manifest as that of the elephant in its jungle, or the camel in the desert.

A remarkable illustration of this appears in the increase of the sponge. At certain seasons of the year, yellow, jelly-like grains sprout from the substance which covers the skeleton of the sponge, projecting more and more, as they increase in size into its cavities—the germs, in fact, of a future race. Each germ assumes an egg-like shape, and a large portion of its surface becomes covered with little hairs called *cilia*—the plural of the Latin name for an eyelash, to which they bear a strong resemblance—all endowed with the power of vibration. And why has the egg-like germ such an appendage? Well may the answer be pondered by those who think that things accounted trivial are beneath the notice of the Great Supreme. These vibrating hairs act as oars to the little germ, to row it away, as soon as it falls on the surface of the



CILIA OF A POLYP.

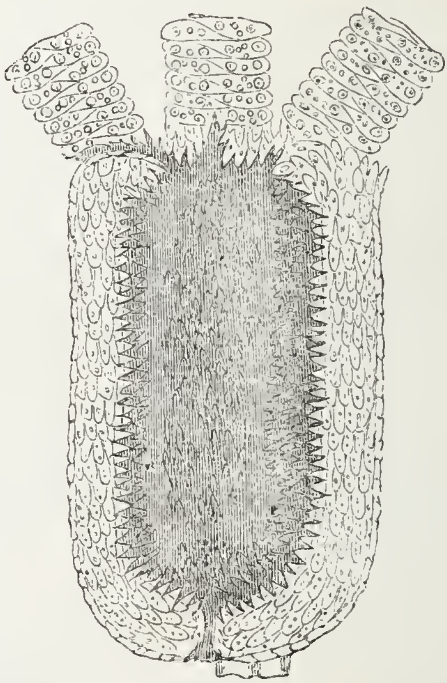
water, from its parent, to some other spot to which it may attach itself; and then, having answered the purpose for which they were expressly developed, the cilia fall off, leaving the germ gradually to develop the peculiar form and qualities of the parent sponge.

We may now glance at the natural history of another very remarkable creature, not only for the marvels connected with it, but also as it will serve to introduce a great diversity of animals to which it is allied in structure. We owe our knowledge of it to M. Trembley. In 1741, he observed certain fibrous bodies adhering to the leaves of some aquatic plants. His first thought was that they were parasites,* but on closer inspection, he discovered that they were endowed with animal life, and continuing his observations, he wrote and published an octavo volume on their structure and habits. Most interesting and amazing are the details of this work, while they suggest to us the important lesson, that a diligent and persevering study of the smallest result of Divine operation will furnish an ample reward, manifesting as it does, equally with the greatest, the power, wisdom, and goodness of the Infinite.

Let the reader imagine that he has cut off from the small quill of a pigeon's feather, about three-

* Such is the misseltoe, which issues from seeds deposited by birds on the exterior of the stems and branches of trees, and so insinuate their root fibres into the wood as to imbibe the ascending sap, and thus to obtain support.

eighths of an inch, and he will have before him the shape and size of the green hydra, discovered by M. Trembley, and which may still be found in weedy ponds, or slowly running streams. Until very recently, a hydra was described as a small



SECTION OF THE BROWN HYDRA—HYDRA FUSCA.

living tube, presenting to the eye merely a gelatinous substance, in which small grains are intermixed. But M. Gervais has studied one of these creatures with all the present advantages of microscopic power, and shows that it is more complex than has been hitherto supposed. When thus highly magnified, the granules are visible in its texture, arranged,

as the reader will observe, in distinct layers, and appropriated, M. Gervais thinks, to different offices. Hence he concludes that while the external layers serve as a covering to the animal, the internal, composed of particles of a conical form, subserve the digestive process. It is, therefore, highly probable, that the structure of the green hydra is no less complicated. Arranged about the mouth are some fine filaments which act as arms.

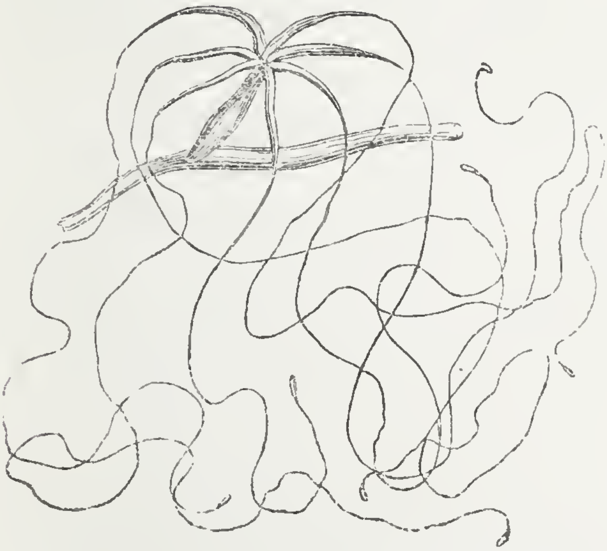
This animal is affected by light, and when confined in a glass, always seeks its brightest side. Its favourite position appears to be that of remaining suspended from the surface of the water, by means of its lower extremity, called the foot. It is manifestly conscious of fear, for when touched roughly, it contracts itself into a small globule, in which state it is secure, as it may easily escape observation. It can wander about the water at pleasure, but its usual mode of proceeding along the stems or leaves of plants is slow. It fixes the sucker of its foot, so as to attach itself firmly, and then gently bending down the body, it describes a semicircle till the mouth reaches another part of the stem or the leaf on which it is stationed; then adhering by the mouth, or the arms arranged about it, it unfixes the sucker, draws it close to the mouth, and fastens it again; once more, it elevates the body, bends it down, and adheres by the arms, and brings the sucker up to the mouth as before, and thus it moves on in slow but certain succession; for a journey of

a few inches, in this way, occupies several hours. A more expeditious progress is therefore effected by a series of somersets. Adhering by the sucker, the latter is detached, but, instead of being brought to the mouth, it is thrown beyond it, as far as possible, describing a semicircle; and a similar movement is then made by the head.

Nor are these its only means of locomotion. In the water the hydra moves with great rapidity. Having crawled to the surface of the water the sucker is protruded into the air; the little animal then contracts its body in such a way as to form the sucker into a kind of saucer. This, of course, being filled with air, converts that portion of the animal into a boat, by means of which the body is suspended from the surface of the water, with its head downwards; the hydra is then drifted along by the current of the stream. Wafted along by the breeze, or grasping objects within the reach of its arms, it propels itself onwards; and then at its pleasure it holds firmly by a stem or a leaf, its little harbour after a voyage, and moors itself into a state of quietude and rest.

The manner in which these creatures obtain food is seen most clearly by watching the movements of the long-armed hydra. If a piece of the stem, or some of the leaves to which these polyps are attached be put into a clear phial filled with water, and placed in a window, they will soon be observed to extend their arms in quest of prey. If a small

worm be then dropped into the water, it will instantly throw itself into violent contortions, as if conscious of danger, while its enemies will be roused into full activity. A hydra will soon be seen to stretch forth its arms, extending them, perhaps, to the length of several inches, and becoming



THE LONG-ARMED HYDRA.

as attenuated as the fibres of a spider's web, and then suddenly seizing and entangling its prey, the victim is instantly paralyzed. Wondrously constructed indeed are these arms; their substance, like that of the body, is jelly-like, and filled with grains; they are tubular, and so arranged that they may be extended or contracted at pleasure; and they are filled with fluid which is no sooner ejected than the prey ceases to struggle.

Most extraordinary is the extent to which one of these creatures may be multiplied. If the upper

part be cut off, it will soon be completed by the addition of a tail; if the tail be cut off, a head with its appendages will as speedily appear. Other divisions will be followed by similar results; and so many additions may be made to one by portions of others, as fully to warrant the appropriation of the name of hydra, first given to an imaginary and many-headed being.

Our countryman, Baker, conducted many experiments of this kind in common with Trembley. Under their observation, no fewer than forty hydras resulted from as many portions. Every part of the animal, excepting perhaps the arms, which failed in their case, is thus capable of forming a perfect hydra. According to Baker, "What is still more extraordinary, polyps produced in this manner grow much larger, and are far more prolific in the way of their natural increase, than those which are never cut. It is very common, when a polyp is divided transversely, to see a young one push out from one or other of the parts, and sometimes from both of them, in a very few hours after the operation has been performed; and particularly from the tail part two or three are frequently protruded in different places and in different times, long before that part acquires a new head, and consequently while it can take in no fresh nourishment to supply them with, and yet the young ones proceeding from it, under these disadvantages, thrive as fast and seem as vigorous as those produced by perfect and uncut hydras."

The extraordinary increase of these creatures has a strong resemblance to that of vegetables, and may be observed if a few of them be kept in a glass of their native water, and well supplied with food. A small bud shoots forth from some part of the parent body, and gradually enlarging, appears like a minute hydra: strange to tell, a portion of the food digested by the parent has been observed to pass into the body of the offspring, but no sooner are the arms of the minute hydra sufficiently strong for the capture of prey, than it contributes in some degree to the support of its parent. On its being equal to an independent existence, it is detached from its parent, and lives apart at its pleasure. The following engraving will throw fresh light on what has now been stated.

THE GREEN HYDRA, OF THE NATURAL SIZE.

It appears erect, walking, under the influence of fear, and with a young hydra sprouting from its surface.

We now proceed to other creatures, whose history is not less wonderful.

CHAPTER VI.

CORALLINES.

The poet Crabbe, fond of visiting the sea-shore, has said:—

> "Involved in sea-wrack, here you find a race,
> Which science doubting, knows not where to place;
> On shell or stone is dropp'd the embryo seed,
> And quickly vegetates a vital breed."

A child, for example, picks up what is unhesitatingly pronounced a piece of sea-weed, and if it have not some striking quality in form or colour, it is hastily, and perhaps contemptuously, thrown away. And yet that object may not be the sea-weed which stands on one of the borders of the vegetable world; on the contrary, it may prove, when duly examined, the uninhabited tenement of numerous animals which have recently quitted it. A large number of these beings were called zoophytes by the older naturalists; the name is of Greek derivation, signifying animal plants, and a difficulty was long felt in assigning to them their proper place among the works of God. Their actual position being now decided, they may be accurately styled "plant-like animals." The distinctive name given to one of these creatures is *polypus*, *polype*,

or *polyp;* we prefer, and shall use as the simplest, the latter term.

An apothecary in Naples, Ferrante Imperato, is said to have been the first naturalist who distinctly declared that some of these were animals. His work was printed at Venice, in 1599. It was afterwards republished, yet so entirely was it forgotten, that when Peyronnet announced the same discovery to the Academy of Sciences in Paris, more than a hundred and twenty years afterwards, it was received by that body as new, and open to the objections usually entertained against what is novel. Most unworthy was the treatment with which he met; and while we deplore it, we cannot but lament that it is one of a multitude of similar instances. When will men, on an assertion being made, ask for the evidence on which it rests; and only when this is unsatisfactory, discard the declaration? Hasty and prejudiced judgments lead to the rejection of many truths, and to the support, perpetuation, and increase of formidable errors.

In the present instance, it ought to have been enough to avert doubt, censure, and obloquy, that Peyronnet dealt not with speculations and fancies, but with actual observation. On the coasts of France, and of Barbary, their native sites, he had carefully studied the polyps which the fishermen brought him after their searches for coral; ascertained that, unlike blossoms or flowers, which some had considered them, they wore the same appearance

at all seasons; and only described what he had actually beheld. Nor was this all, he did not stop at the examination of their form and movements. by chemical analysis, he had discovered in polyps the constituent principles of animals and that the stony part bore no trace of vegetable organization: he had found, moreover, that as they decayed the odour of animal substances was exhaled. But prejudice has neither eyes nor ears, and is equally deficient in attention and judgment.

Our countryman, John Ellis, already mentioned, is also entitled in this connection to honourable mention. Accustomed to amuse himself by skilfully and curiously arranging sea-weeds and corallines on paper, he was led by the beauty and elegance of the latter, to examine them minutely by the aid of the microscope. It was now instantly manifest that they differed not more from each other in form, than they did in texture, and that in many of them there were indications of a nearer alliance to an animal than a vegetable nature. Encouraged by some of the members of the Royal Society he prosecuted his inquiries with great ardour and sagacity, and soon convinced himself that "these apparent plants were ramified animals." His essay on corallines and other marine productions commonly found on the coasts of Great Britain and Ireland, is a work which does him great credit.

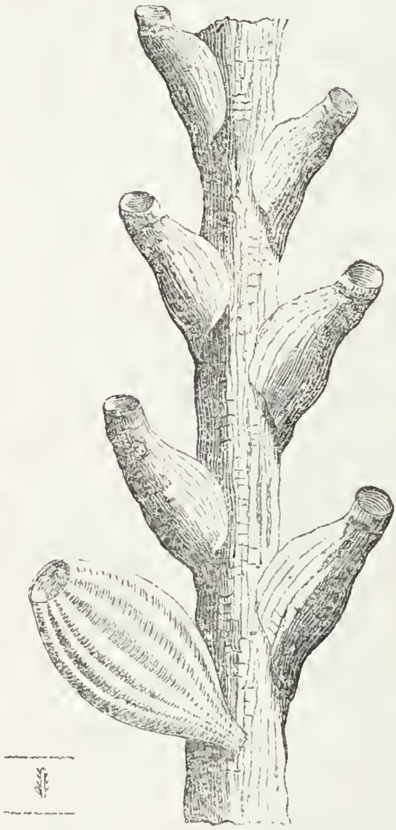
The researches of Ellis left no space for doubt. By the aid of a microscope, he saw the living

polyps in their cells; he observed their sensibility to outward impressions; he witnessed their various actions, and particularly their stretching forth their petal-like arms for the capture of prey. It was proved, moreover, that other functions were exercised, and the process of digestion was watched through its different stages. These discoveries tended ultimately to set at rest the question which had been vibrating in doubt for more than a century.

SERTULARIA LENDIGERA.

A particle of one of these corallines, no larger than the little figure placed at the side of the engraving, when seen in the microscope, exhibits a remarkable animal structure. There is a central stem from which branches diverge, which may be

pulled out to the extent of two or three inches, each of which is furnished with a row of cells containing polyps.

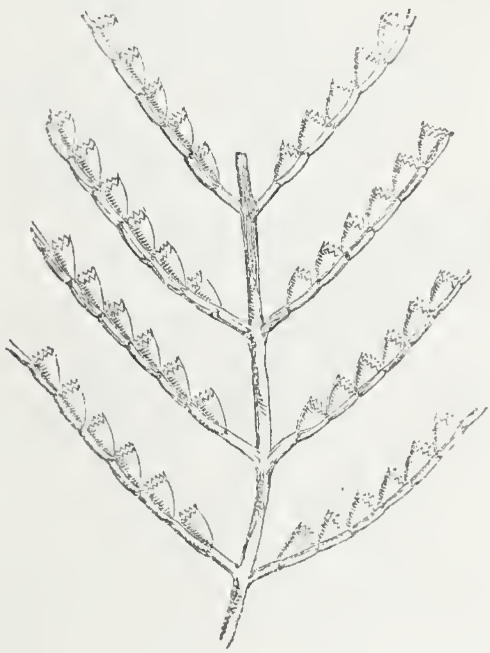

SERTULARIA ABIETINA

Another is very elegant: it adheres by its tubes to most kinds of shells, and also to stones; it grows very erect; and is frequently infested with minute shells. It consists of a central stem, around which several cells appear, each one opening into it, and being the tenement of a separate polyp. This coralline rises to the height of eighteen inches, and is of common occurrence.

Another example shows a very different structure, which the engraving represents as highly magnified. This coralline, observed on mussels and other shells, is common on the southern coasts of England, and is to be found also on those of Ireland and Scotland. It is frequently seen attached to seaweeds by a flexuous, horny, tubular fibre, in colour like mother of pearl, which throws up at intervals plumous shoots, from an inch to an inch and a half in height. They are very

elegant and erect when in the sea, and when dry, become curved. They have been aptly compared to the flower of the lily of the valley, having the rims cut into eight equal teeth.

"Each plume," says Lister, in reference to a specimen of this species, "might comprise from four hundred to five hundred polyps." Another described by Dr. Johnstone, of no unusual size, had



SERTULARIA PLUMA.

twelve plumes, with certainly not fewer cells on each than the larger number mentioned, thus affording habitations to six thousand polyps. In a specimen taken by Mr. J. D. Dana, in the East Indies, there are about twelve thousand polyps

to each plumose branch; and as the whole zoophyte, being three feet long, bears these plumes, on an average, every half inch on opposite sides, the whole number of polyps is not less than eight hundred millions; all the offspring of a single germ, and produced by successive buddings.

Lister mentions a curious fact in reference to one of these corallines:—"After I had kept the clusters in a large bowl for two days, I observed the animals to droop and look unhealthy. On the third day, the heads were all thrown off, and lying on the bottom of the vessel, of a pink colour, and when it had stood quietly for two days, it became a very fine powder. Thinking that the tubes were dead, I was going to throw them away, but I happened to be under the necessity of quitting home for two days, and on my return, I found a thin transparent film being protruded from the top of every tube. I then changed the water every day, and in three days every tube had a small body reproduced upon it. The only difference I could discover in the structure of the young from the old heads, consists in the new ones wanting the small red papillæ with which the others are provided, and in the absence of all colour in the animal!"

A variation from the last-noticed form is apparent in another coralline, which adheres to rocks and shells near low-water mark, and is also found in deep water. This elegant species, which is very common,

rises frequently to the height of eighteen inches, in wide spiral turns, and sends out from its stem a series of cells and, at regulated intervals, spreading

PLUMARIA FALCATA.

branches, which are placed one above another on the outer side. The size of the specimen placed in the microscope, is shown at the side of the engraving.

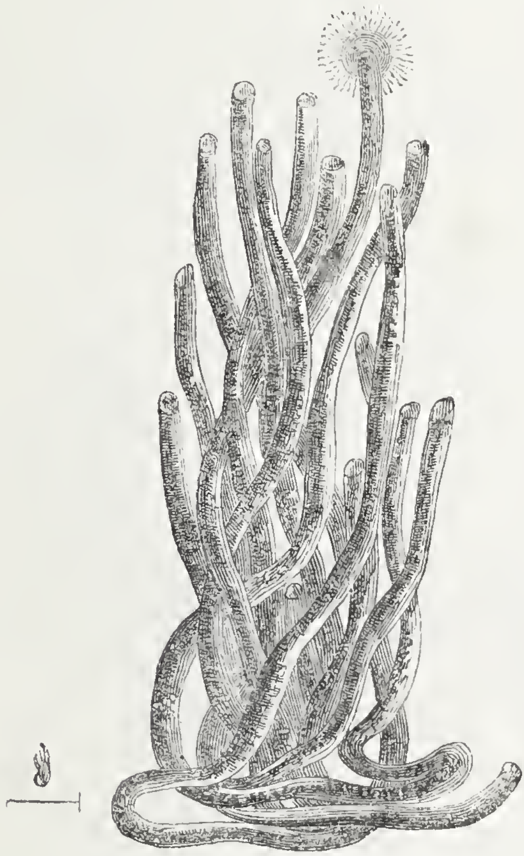
Another variety among corallines is common on some parts of the British coasts, near low-water mark, on aquatic plants. The representation now given, like some others, was drawn from a specimen by Mr. Boswell of Ozengall, near Ramsgate, who has

DYNAMENA OPERCULATA.

collected a great diversity of these minute beings from that part of the southern coast. It grows from two to four inches high. The shoots are slender, and always erect; the polyp cells are exactly opposite. Each of them is provided with a lid, whence the name of this coralline is derived. The outer angle of the aperture of the cell is produced into an acute point, and there is a sharp tooth on each side.

We now proceed to a form unlike any already noticed, which is found on shells and stones in deep water, on our southern coasts, in the north of England, and also in Scotland. The tubes are simple, about as thick as a common sized pin, but some are almost, or quite as large as those in the engraving. They are sometimes divided at the base, where they are twisted and flexuous, sometimes wrinkled at distinct intervals, horn-coloured, and from six to twelve inches in height. Ellis

describes one of these tubes as like part of an oat straw with the joints cut off. They are filled with a soft, almost reddish pink pulp; the polyps project from the open ends of the tube, and are not retractile



TUBULARIA INDIVISA.

within them. The body, or naked portion of the polyp, forms a globular knot of a scarlet colour, produced above, into a sort of proboscis, encircled with a series of short arms of the same character. Around the base of this body there is another circle of much longer arms, from thirty to forty in number. The

neck of the polyp is greatly constricted. A recent tube is marked with several longitudinal pale lines, placed at equal distances, which are evidently caused

CAMPANULARIA VOLUBILIS.

With a Sickle Coralline, so called from its resemblance to that instrument.

by some structure of the internal pulp, for, when empty, the tubes exhibit no such appearance. As the animal becomes weak when kept in a basin of sea water, the head drops off like a flower from the stalk; and if it is immersed, even when most

vivacious, in fresh water, the pulp is expelled from the tubes till they are almost emptied.

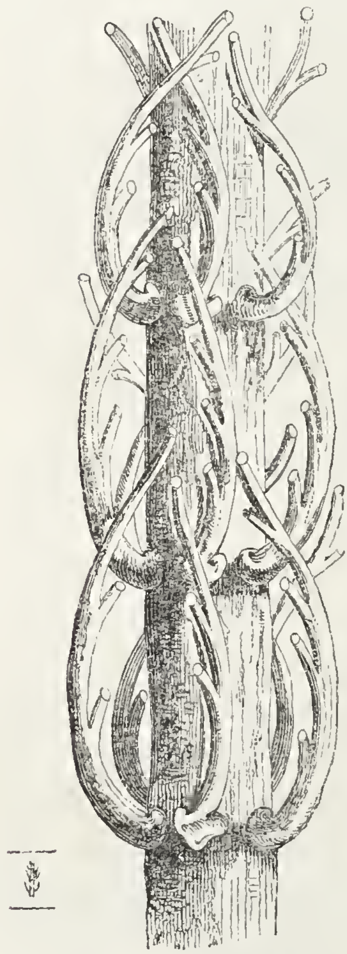
But though the head falls soon after recovery from the sea, according to Sir J. G. Dalyell, it is renewed at intervals of from ten days to several weeks, but with the number of external organs successively diminishing, though the stem is always lengthened. It seems to rise within the tubular stem from below, and to be dependent upon the internal tenacious matter with which the tube is occupied. A head springs from the remaining stem, very near the root; and a redundance of heads may be obtained from artificial sections, as in the instance of the hydra already described, apparently beyond the ordinary provision of nature. Thus twenty-two heads were produced in the course of five hundred and fifty days, from the sections of a single stem.

Johnstone says, of the coralline now presented, "I have seen the antennæ of a crab so profusely infested with this zoophyte as to resemble hairy brushes. The creature had chosen, in this instance, a station where it had all the advantages of locomotion. This species is very minute. The stem is a hair-like, horny tube, which creeps and twists itself upon its support, throwing out at alternate intervals a long slender twisted stalk, that supports a bell-shaped cup of perfect transparency, and prettily serrulated round the brim."

The stems of another coralline* are clustered; it

* Antenularia ramosa.

is erect, straight, cylindrical, of a clear yellowish horn colour, irregularly branched or undivided, and attaining the height of eight inches. The branches, when dried, resemble the antennæ of a lobster. They are exceedingly like the primary shoot, equally furnished with hair-like branchlets, and arranged in numerous whorls. They carry the polyp cells, which are distinct and small, with entire rims, and divided from each other by a joint.



ANTENULARIA RAMOSA.

Thus far we have traced a very remarkable structure of microscopic beings. We have seen in several instances a series of cells, each one the habitation of a polyp, and having often a marked peculiarity of form, arranged in exact but varied order about the central stem. Another wonder now demands especial notice; for a living thread runs through not only the stem of every coralline, but also every branch, constituting in fact, of the whole structure, one living animal. The polyps are merely the active auxiliaries to its existence and support. It used to be said that the jackal was

the lion's provider, and the polyps may be represented as the jackals of the coralline. How marvellous are the arrangements of this complicated being! We have not a solitary coralline, to be contemplated on taking it from the waters, but one of a long series of greatly diversified species, each one having some peculiarity, and not unfrequently many, by which it may be easily distinguished from all others. Every peculiarity answers moreover the design of the All-wise and Supreme Artificer, and shows how minute are the arrangements he makes for the existence and continuance of the humblest of his creatures.

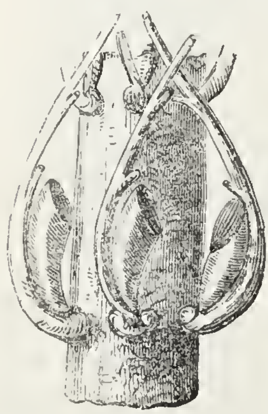
VESICLES OF THE SERTULARIA PRIMATA.

Nor is the tale of wonder yet finished. For, as the eye dwelt upon the engravings over which we have just passed, it could not fail to notice other objects to which as yet no allusion has been made.* These are vesicles, which are apparent on corallines in the spring of the year, and exhibit, in common with every other part of such structures, great variety. The vesicles of the *Sertularia abietina* are scattered, smooth, and have a tubulous mouth. They are always on the upper edge of the branch from which they originate. In *Plumaria falcata*, they

* See pp. 58—62.

SERTULARIA TAMARISCA.

SERTULARIA POLYZOMA.



VESICLES OF THE ANTENULARIA RAMOSA.

are scattered irregularly on the branches, stalked, ovate, or pear-shaped, with a short tubulous aperture, and occasionally wrinkled longitudinally, when dry. In the *Sertularia pluma*, they are large and remarkably curious: they are produced from the main stalk, and resemble a swollen pod, girded round with from five to nine ribs or bands, proceeding from a dorsal tube, and rising into short spines on the anterior margin; when recent, they are translucent. The vesicles of the *Dynamena operculata* are large, smooth, egg-shaped, the top often covered with a sort of rounded lid. On the *Tubularia indivisa* clusters of oviform gemmules appear at certain seasons. The vesicles of the *Antenularia ramosa*, on the contrary, are attached to the central stem, and not to the branches.

The vesicles, of which only a few specimens have now been given, are the seed vessels of the future race. Here the germs float

about in a fluid. In one case described by Dr. Grant, they are large, of a light-brown colour, semi-opaque, nearly spherical, composed of minute transparent granules, ciliated on the surface, and distinctly irritable. On placing an entire vesicle, with its germs, under the microscope, the cilia were seen through the transparent sides, actively vibrating, and the currents that were produced in the fluid within, by their motion. When the vesicles were opened with needles in a drop of sea-water, the germs were observed to glide to and fro through it, at first slowly, and afterwards more quickly, the cilia propelling them, with the same part always forward.

They are highly irritable, and frequently contract their bodies into singular forms. This is especially observable when they come into contact with a hair, a filament of seaweed, a grain of sand, or any other minute object. Such changes are likewise frequently observable when a germ is busied in attaching itself permanently to the surface of the glass. After the germs are fixed, they become flat and circular, and their more opaque parts radiated, so that they now appear, even to the naked eye, like so many minute grey-coloured stars, having the interstices between the rays filled with a colourless transparent matter, which seems to harden into horn. The grey matter swells in the centre where the rays meet, and rises perpendicularly, surrounded by the transparent horny matter, so as to form the

stem of the future zoophyte. The rays first formed are the fleshy central substance of the roots, and the portion of that substance which grows perpendicularly, forms the fleshy part of the stem.

What surprising metamorphoses do we witness in the animal kingdom! In one part of it we hear a voice directing us to trace the course of "the helpless crawling caterpillar,"

> "Which to the tomb a willing guest descends.
> But when revolving months have won their way,
> When smile the woods, and when the zephyrs play,
> When laughs the vivid world in summer's bloom,
> He bursts, and flies triumphant from the tomb;
> And while his new-born beauties he displays,
> With conscious joys his alter'd form surveys."

Well might the poet add:—

> "And deems weak man the future promise vain,
> When worms can die, and, glorious, rise again?"

But in the history of these corallines we see germs provided with cilia in constant rotatory motion, by which their birth seems to be facilitated; and when at liberty in the water, moving and swimming about as if they were guided by volition and sense, whirling at the same time on their own axis. This freedom of motion may continue for several hours, or even for two or three days, before a proper site for permanent stay and future growth is found. Yet this being determined, they become fixed corallines, and begin to shoot up into those beautiful forms, which the Supreme Being has ordained in accordance with their particular species.

While growth and reproduction are proceeding in the coralline, the older parts of it die. The polyps disappear, and the lower branches frequently drop off, leaving the trunk in this part bare. Thus budding and dying are simultaneous in different parts of corallines. In the large species, the main stem or midrib becomes lifeless, or the mere support for the numerous lateral plumes or branchlets.

Some of these polyps are said to be absorbed in their cells, and after a while to reappear. This fact has been observed to occur at nearly regular intervals. Thus all the cells of a living group have been found empty after a certain period, or with only the remains of the wasted polyps, the whole evidence of vitality being the continued vibration of the fluid of the trunk. The polyp heads seem to drop off like a deciduous flower, yet, after ten days or more, they are reproduced. Harvey observes, that after he had kept a *Tubularia* two days, the heads began to look unhealthy, and on the third they were thrown off, and lay at the bottom of the vessel. After another three days, during which the water was changed, the polyps were entirely renewed, with no essential difference except the absence of colour. The cold of winter is said to strip off sometimes the polyp flowers, which remain apparently dead till spring, when the coralline is warmed anew into life, and the flowers are once more apparent.

According to Van Beneden, some corallines, when

first developed, are like little medusæ, or jelly-fishes in shape, and have eight eyes, which are lost as the animal attaches itself to some object. Sir J. G. Dalyell, who had previously observed their forms, states that the young, after the arms are formed, advance by means of them, and being inverted, move as on so many feet, apparently to select a site; when, again resuming the natural direction of the arms, the lower surface fixes itself, and the animal becomes rooted there for the whole time of its being.

The polyp cells of *Laomedia gelatinosa* are deeply cupped, transparent, with a wide, even margin. The vesicles are urn-shaped, and smooth, shooting from the axils of the pedicles; they are matured during the summer months, "when," says Dr. Johnstone, "we find them filled with ova of a circular, flattish form, marked with a dark speck in the centre. At first they fill not more than half of the vesicle, but by their increase in size, they soon come to fill the whole cavity, and are ultimately extruded from the top, after which the empty vesicle soon disappears. The ova, while in the vesicle, are arranged round a central column, and the lid which closes the vesicle, is a mere expansion of this column, which appears to be composed of two pieces soldered together, where, perhaps, the ova are more immediately affixed in their immature state.

The polyps have about twenty long arms roughened with minute tubercles, placed in whorls.

In their centre is the mouth, which sometimes assumes the shape of a rounded projecting tubercle, at others of a narrow column, and sometimes of a broad flat disc with a stricture under it, simulating a neck. It leads directly to the stomachal cavity, which is large and undivided, and I have occasionally witnessed within it currents of a fluid filled with minute granules that has been more fully noticed by Mr. Lister and Dr. Fleming."

How exquisite are these marvellous arrangements of Infinite Wisdom! In microscopic beings, we discover a variety of essential and important parts and movements, the organs of which we have as yet no power to trace. Still it is truly said—

> " The minutest throb
> That through their frame diffuses
> The slightest, faintest motion,
> Is fix'd and indispensable
> As the majestic laws
> That rule yon rolling orbs."

As many zoophytes are phosphorescent, they may well be described as

> " Spangling the wave with lights as vain,
> As pleasures in this vale of pain,
> That dazzle as they fade."

Dr. Johnstone says,—" Every member of one family is luminous, at will, perhaps, although they light up their tiny lamps apparently when under the influence of some painful irritation; will-o'-the-

wisps of the sea, put out to frighten feeble assailants."

Crabbe has noticed the same effect. In describing sea-side objects, he says with great truth :—

> " While thus with pleasing wonder you inspect,
> Treasures, the vulgar in their scorn reject,
> See as they float along the entangled weeds,
> Slowly approach upborne on bladdery weeds;
> Wait till they land, and you shall then behold
> The fiery sparks, those tangled fronds infold
> Myriads of living points; the unaided eye
> Can but the fire, and not the form descry."

The naturalist appears more clearly in these words than the poet, for if a leaf of the *Fucus seratus* with the *Sertularia* upon it, receive a smart stroke with a stick in the dark, the whole coralline is most beautifully illuminated, every denticle appearing to be on fire.

CHAPTER VII.

THE SEA ANEMONE AND MOSS CORALS.

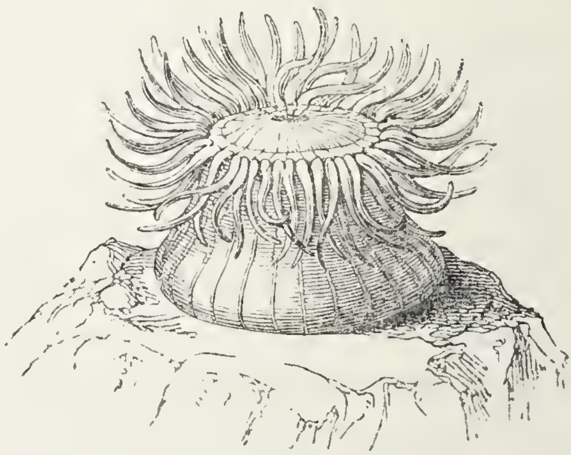
It is delightful to visit the shores of the ocean, when the heat of mid-day is past, and the refreshing sea breezes invigorate the frame. Such circumstances are the last in which the lover of nature can be idle; for there may be observed beings of which there are countless multitudes, varying in form, character, and habits, all exhibiting the perfections of Him who called them into existence.

If, for example, in our walk on the sands of the seashore, when the retiring tide has left bare a low cluster of weed-covered rocks, with little pools between, we have an opportunity of observing a species of polyp frequently found there, it will be well to examine the little creature. It is the *Actinia;* and from the radiation of its arms, which may be distinctly observed on its upper surface, it has been called the sea anemone, the sea sunflower, as well as other names, indicative of similarity.

The actinia consists of a soft, fleshy, cylindrical body, attached by its base to the surface of the rock, the opposite extremity having a mouth, surrounded by several rows of arms, which can expand, contract, or move about, as may be required.

The appearance of the actinia is very beautiful

when the arms are fully expanded, and the effect is increased by the fine colours which they often assume, and which vary in different individuals.



THE SEA ANEMONE, OR ACTINIA.

These animals are endowed with great sensibility, contracting not only when touched, however delicately, but even when a dark cloud passes over the sky, as if apprehensive of impending danger from the sudden obscuration of the light. They can lengthen their bodies, and turn with expanded arms from side to side, either to enjoy the rays of the sun, or in quest of prey. If a person endeavours to disengage them from the rock to which they are attached by their sucker-like base, they forcibly contract themselves into a firm round mass, with a slimy surface, and are not easily removed without injury. They are not, however, so fixed that they cannot change their situation; they can slowly glide upon the surface of the rock, or they can become detached entirely, and

filling themselves with water, so as to be nearly of the same specific gravity as their native fluid, suffer themselves to be carried by the current to another spot; and it has been asserted, that they can turn themselves, and crawl about by means of their tentacles.

The actinia is very voracious: it preys on animals with which it might appear to be totally unfit to contend, such as crabs; and for these it waits with expanded arms, ready to grapple them at the moment of contact. In clear water, it may be watched thus engaged; and it is curious to observe the wandering crab instantaneously brought within the grasp of these arms and pertinaciously grasped, the arms closing gradually around it, and by their contraction forcing the prey within the mouth, which opens to devour it. It endures, however, long abstinence without apparent inconvenience, though it is probable that the animalcules, which abound in the water, may contribute in some slight degree to its nourishment. Yet it may be preserved in a vessel of sea water, duly changed, for upwards of a year without having visible food; but woe to the mussel or crab that is offered for its reception! A crab as large as a hen's egg, or two mussels, shells included, will serve an actinia for a meal. The work of digestion is rapid: in two or three days the shells will be disgorged, not a particle of the soft contents of the prey remaining.

Mr. Bennett in his "Wanderings," states a re-

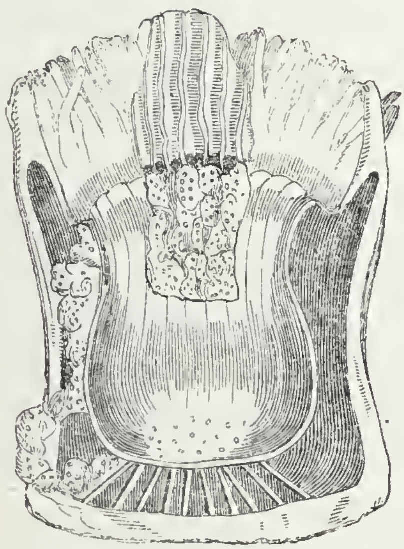
markable fact in reference to one of these creatures. "I had once brought to me an actinia* that might have been originally two inches in diameter, and that had somehow contrived to swallow a valve of the common scallop,† of the size of an ordinary saucer The shell fixed within the stomach was so placed as to divide it completely into halves, so that the body, stretched tensely over, had become thin and flattened like a pancake. All communication between the inferior portion of the stomach and the mouth was of course prevented; yet, instead of emaciating and dying of atrophy, the animal had availed itself of what had undoubtedly been a very untoward accident to increase its enjoyments, and its chances of double fare. A new mouth, furnished with two rows of numerous arms, was opened upon what had been the base, and led to the under stomach. The individual had, indeed, become a sort of Siamese twin, but with greater intimacy and extent in its union!"

The external part of the actinia consists of bundles of muscular fibres, running in various directions, some perpendicularly, others transversely. In the intervening spaces between these fibres thus interlaced, are numerous small granular bodies, which are universally distributed, except on the sucking base or disc. Over this tissue is a mucous layer, forming a species of outer skin, which appears to be thrown off at intervals and renewed. The stomach,

* Actinia gemmacea. † Pecten maximus.

a simple membranous sac, seems to be a continuation of the external tissue.

The arms, of the same structure as the body, are tubular, having a minute orifice at their extremity; and their interior communicates with a compartment between the stomach and the external tissue, or wall of the body. This compartment is divided by longitudinal membranous partitions into numerous chambers, between which there is a free communi-



SECTION OF ACTINIA.

Showing the chambered cavity with the eggs on the left.

cation. This chambered or divided cavity is the respiratory or aërating receptacle, and is filled with the sea water taken in through the arms, and expelled by them when the animal contracts; a fresh supply being absorbed on the dilating of the body. It appears to be thus under the creature's volition;

and it has been observed, of examples kept in vessels, that as the fluid in which they are confined becomes deficient of air, and consequently less fitted for the purpose of aquatic respiration, they fill themselves with it almost till they burst, and resemble inflated bladders. This is evidently done because it is only in a great volume of such fluid that the quantity of air necessary for the support of life, and which a much smaller volume of unexhausted water would supply, is now contained.

In these respiratory compartments, the eggs are arranged in clusters on a delicate convoluted membrane; and it appears, that on being detached from it, they either pass, by means of a minute orifice, into the bottom of the stomach, whence they escape, or are transmitted through the arms. It is said by some authorities that the eggs are hatched internally, the young being extruded; by others, that the eggs are hatched after expulsion. There is, however, much in the economy of these animals yet to be investigated.

The actinia has a power of reproduction equal to that of the hydra. Any one may be divided, each part becoming a perfect animal; but when cut asunder transversely, the basal portion is about two months in gaining its rows of arms.

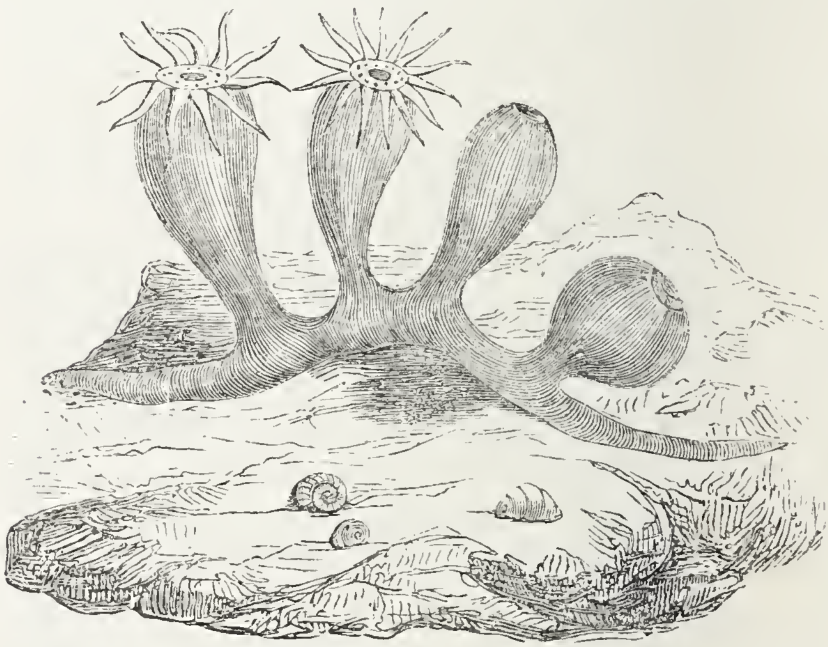
Hughes, in his Natural History of Barbadoes, describes some of them as found in a sub-marine rock basin. "In the middle of it," he says, there is a fixed stone or rock, which is always under

water. Round its sides at different depths, seldom exceeding eighteen inches, are seen at all times of the year, issuing out of little holes, certain substances that have the appearance of fine radiated flowers, of a pale yellow, or a bright straw colour, slightly tinged with green, having a circular border of thickset petals, about the size of, and much resembling, those of a single garden marigold, except that the whole of this seeming flower is narrower at the setting on of the leaves than any flower of that kind."

After describing various unsuccessful efforts to capture one, the same writer adds :—

"I once cut off—with a knife which I had held for a long time out of sight near the mouth of a hole out of which one of these animals appeared—two of these seeming leaves. These, when out of the water, retained their shape and colour; but being composed of a membrane-like substance, surprisingly thin, it soon shrivelled up and decayed. Many people coming to see these strange creatures, and occasioning some inconvenience to a person through whose grounds they were obliged to pass, he resolved to destroy the objects of their curiosity. That he might do so effectually, he caused all the holes out of which they appeared, to be carefully bored and drilled with an iron instrument, so that we cannot suppose but their bodies must have been entirely crushed to a pulp: nevertheless, they appeared in a few weeks from the very same places."

In ordinary circumstances, the young, already formed, are seen issuing, sometimes from the mouth; and at others the base of the parent is dissevered, a portion remaining attached to the rock, where it continues to live, increasing in size, becoming more and more rounded, while in a short time, a mouth, stomach, and arms are formed, presenting to the



ZOANTHUS.

well-grounded astonishment of the observer, a complete actinia. At length, the side portions of this base give out globules, which being detached, fix themselves on adjacent rocks, where they grow, and form a new colony like the parent animal.

Each species generally selects a peculiar haunt,

but they are found in every sea; many of them being used as food in tropical countries, on whose coasts they are more numerous than in colder climates. Some appear suspended from the vaults of submarine reefs, others covering the more exposed sides of rocks with a sort of flower, like tapestry, and others confining themselves to the smooth sands.

Nearly allied to the genus *Actinia* is that termed *Zoanthus;* the polyps, indeed, closely resemble the actinia, but they are united together on a common base, and are therefore, individually, not so independent.

There is a large class of animals, almost all of microscopic minuteness, often called *Bryozoa*, or moss corals. Of these, hundreds of microscopic fossil species have been recently detected by the researches and unwearied labours of Ehrenberg and d'Orbigny; and it would appear that their shelly cases, or cells, enter into the composition of chalk beds, compact mountain limestone, the flints of the Jura limestone, the sea sand of Europe, the Mauritius, the Sandwich and adjacent islands, and the sands of the Libyan desert. Many are invisible to the naked eye; others resemble minute grains. Of these fossil forms of *bryozoa,* not a few are found still existing in a living state. Ehrenberg has determined fifty-seven species in the Adriatic sea and open ocean to be identical with fossil species.

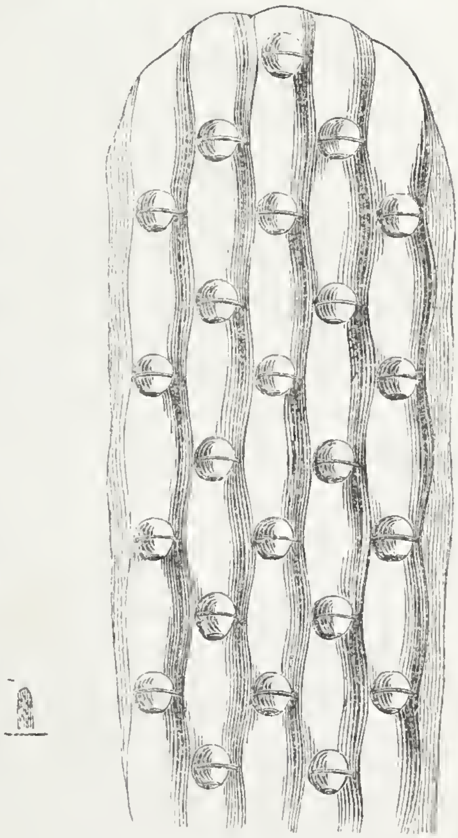
Some idea of the minuteness of various species of these fossil moss corals may be formed, when it is known that in the finest levigated whiting, multitudes are present, without having suffered change in the preparation of the chalk; and that, by the aid of the microscope, a mosaic work of moss corals may be seen, of varied and beautiful forms, on the chalk coating upon the walls of a room.

The best way of observing these minute fossils, is to place a drop of water on a delicate film of mica, and add to it as much of fine chalk powder as the top of a penknife will take up. Let this be spread out like a very thin layer, the water be drained off, and with it the floating particles. When the layer is quite dry, it should be coated over with pure Canada balsam, holding it during the addition of the balsam over a spirit lamp till it becomes slightly fluid; but clear and without froth. In the management of this, some dexterity and practice are requisite; but when effected with delicacy, the preparation generally proves successful.

Some of the moss corals appear as a cluster of minute cells, or open vesicles, of a calcareous structure, forming patches of greater or less extent, on all marine productions, vegetable, animal, or inorganic. Their minuteness often causes them to be overlooked by the ordinary eye, nor is their true character to be discovered except by microscopic examination, when they are seen distinctly as clusters or groups of cells. Each of the cells is

hinabited by a polyp, which extends at will its ciliated arms.

The *Flustra carbacea* or flaxen flustra, is found on shells from deep water on the southern coast, on that of Durham, on Leith shore, and on the coast of Ireland. It is fixed by a small disc, narrow at the base, with thickened margins dilating upwards, and becoming very broad in proportion to the height, which at most is about two inches; it is thin, yellowish brown, deeply divided, and the segments are broad, and somewhat rounded at the apex.



FLAXEN FLUSTRA. FLUSTRA CARBACEA.

The cells on one side are large and smooth, the polyps have about twenty-two arms, which are nearly one-third of the length of the body, and there appear to be about fifty cilia on each side of an arm, making 22,000 cilia on each polyp. In this species there are more than eighteen cells in a square line, and 1,800 in a square inch of surface, and as the branches of an ordinary specimen

present about ten square inches of surface, it has more than 18,000 polyps, 396,000 arms, and 39,600,000 cilia. Often in such observations are we reminded of the words of Lucretius:—

> "How many animals whose middle part
> The sharpest eye can't see!
> How, then, each little member of the whole!"

In the *Flustra foliacea* there are at least twice as many, or 36,000 living beings, all actively employed in the seizure of food, all working their arms, and rapidly vibrating the cilia which cover them.

POLYP OF FLUSTRA CARBACEA.

Others present stems or leaves of a horny texture, sometimes cellular on one side only; sometimes on both. The large foliaceous flustra, just mentioned, has cells on both sides, with elevated margins; the margin of each being armed, at its upper part, with two spines. The extension of the cells of the flustra takes place laterally, the innermost, or most central, being often destitute of polyps, while the external series of cells is tenanted. The aperture of each cell of the *Flustra foliacea* is defended by four projecting spines, which arise from the calcareous margin of the cell. There are two spines on each side of the aperture; the upper two being twice the length of the lower pair, and slightly

curved upwards. When we look transversely on the surface of a branch, the spines appear to be arranged in very regular transverse curved rows; and when we observe the surface longitudinally, they appear to be arranged in very regular longitudinal straight lines.

The spines are calcareous, tubular, cylindrical, shut at their extremity, and obviously appear intended to protect the expanded polyp. The two pairs of spines belonging to each cell are placed on the upper half of the cell, though from the contiguity of the cells, the lower half of each is likewise defended by the spines of the adjacent cells, so that they also serve to protect the polyps when in a retracted state. No projecting spines of this kind are found in the *Flustra carbacea.*

According to Dr. Farre, the transparent horny cell which closely embraces the body of the animal is nearly unyielding in its lower two-thirds, but terminates above by a flexible portion, which serves to protect the upper part of the body when the whole is expanded, in which state it is of the same diameter as the rest of the cell; but when the animal retracts, is folded up and drawn in after it, and completely closes the mouth of the cell.

The flexible part consists of two portions: the lower half being a simple continuation of the rest of the cell; the upper, consisting of a row of delicate bristle-shaped processes, which are arranged parallel with each other round the top of the cell, and are

prevented separating beyond a certain distance, by a membrane of excessive tenuity, which surrounds and connects the whole. This mode of the termination of a cell is one of constant occurrence, and is evidently a provision for allowing of the freest possible motion of the upper part of the body in its expanded state, to which, at the same time, it affords support and protection.

The aperture of the cells in the *Flustra foliacea* is formed by a semicircular lid, convex externally, and concave internally, which folds down when the polyp is about to advance from the cell. The opening of this lid in the *Flustra truncata*, where it is very long, appears, Dr. Grant tells us, when seen through the microscope, like the opening of a snake's jaws, and the organs by which this motion is effected are not perceptible. The lid of the cells opens and shuts in *flustræ*, without the slightest perceptible synchronous motion of the polyps.

Hooke, in his *Micrographia*, says: — "For curiosity and beauty, I have not among all the plants or vegetables I have yet observed, seen any one comparable with this seaweed," referring to the *Flustra foliacea*. When recent it exhales a pleasant scent. Pallas compares it to that of the orange; Dr. Grant, to the perfume of violets; and a friend of Dr. Johnstone's, to the mingled odour of roses and geraniums.

In the vesicle of the *Flustra carbacea*, there is but one egg, and as it enlarges it rises higher, till, in

its mature state, it occupies the broad upper part of the cell. When it has thus gained the summit, we may observe a distinct wide helmet-shaped capsule, surrounding it and separating it from the cavity of the cell. On examining the egg within this capsule by the microscope, we perceive its cilia in rapid motion, and Dr. Grant has frequently seen the egg in this situation contract itself in different directions, shrink back in its capsule, and exhibit many signs of irritability before its final escape. The helmet-shaped capsule is open at the top, and connected with the aperture of the cell, so that the egg readily escapes by contracting its body and moving its cilia. On escaping from the cell, the egg glides to and fro by their action, and after fixing, it is changed into a single complete cell, from which new cells shoot forward. Polyps make their appearance in short sacs at the bottom of the new cells, when they are sufficiently forward to protect them. When the egg has escaped from the cell, the dark round spot in the centre of the cell enlarges, and the new polyps shoot out from that point, so that at the proper season we may observe young polyps in every situation of the branches; the whole of the old cells are thus never found entirely deserted, the same cells may repeatedly produce eggs and polyps, and the whole zoophyte retain its energy for several seasons.

With regard to the cells of these polyps, it must be observed that they constitute an *integral* part of

the animal itself; they are not, like the shell of the snail, merely a calcareous, or horny deposition, moulded on the body of the animals, but are, in fact, a portion of the tegumentary covering of the polyps, which, by the secretion of calcareous particles in its tissue, assumes a firm consistence, without ceasing to receive nutriment. Thus, then, the cells clustered together, form a vital and organic bond of union between the polyps, which may be regarded as so many seizing and digesting organs, labouring for the good of the general mass, or common skeleton.

At different ages, the cells undergo certain modifications of form; a proof that they are in vital connection with the animal, and not extraneous. In species where the young spring from the sides of those first formed, and there remain, examination will satisfy that the configuration of the cells not only changes with age, but that it is upon the external surface that these changes are chiefly effected. If, then, we take up a *flustra*, (as *F. foliacea*,) we may regard the whole, with justice, as a living skeleton, "presenting a long series of generations linked to each other;" the relative ages of the individuals, composing the general whole, being indicated by the position they occupy; those along the margin, and at the extremity, being the last produced. We sometimes observe parts in calcareous zoophytes, possessing distinct powers of motion, though apparently unconnected with the body of the polyp. Thus in the *Cellaria avencularia*, whose polyps have

the same structure and the same connection with the cells as the *flustræ*, Dr. Grant has observed in living specimens a constant motion of flexion and extension in certain remarkable testaceous processes, shaped like a bird's head, and attached by a kind of stem to the outside of all the cells. These processes and organs are likewise provided with lateral folds, like the valves of a shell, which have a distinct and regular motion corresponding with the flexion and extension of the entire process.

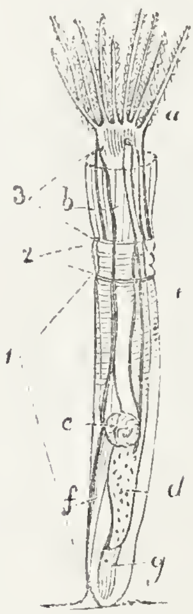
One genus* comprehends a very singular group of moss corals, of which the cells, in dense clusters, are irregularly scattered on the stem, which is usually attached to the common seaweed.† The best known species is the *Bowerbankia densa* of Dr. Farre. In its early stage of development, the cells do not spring from a stem, or raised polypary, but spread in a single layer over the surface of the seaweed; and afterwards, a stem rises. Mr. Hassell gives a figure of the perfect zoophyte, from which the annexed figure is taken.

It is, however, to Dr. Farre that we owe our knowledge of the structure of this singular animal; his account, which refers to the immature of the species, we shall give as briefly as possible.

The polyp inhabits a transparent horny tube, about a line in length; and of these tubes, small clusters, arising from a common base, may not unfrequently be detected. When protruded from the

* Valkeria. † Fucus vesiculosus.

orifice of its tubular cell, the polyp spreads out ten long slender arms surrounding the mouth. On their outer surface is a row of stiff spines; and besides these, a number of minute vibrating cilia, which are thrown continually into the most rapid movements, so as to produce a vortex, a mimic whirlpool, gyrating to the mouth, and carrying with it particles of food. Sometimes the arms themselves grasp minute objects, and draw them in. The mouth surrounded by the arms, *a*, is a simple orifice leading into a capacious gullet, *b*: this gradually narrowing, terminates in a muscular gizzard, *c*, of a rounded figure, with fibres radiating from two dark spots, and internally furnished with minute bruising teeth. To this succeeds a stomach, *d*, apparently furnished with numerous glands.



POLYP AND CELL OF VALKERIA IMBRICATA, (*immaturo.*)—1. Horny base. 2. Soft part of tube. 3. Bristles, supporting a filmy transparent web.

The intestinal canal, *e*, emerges from the upper portion of the stomach, and running upwards, terminates below the base of the arms. When the animal withdraws into its cell, by the aid of certain muscles, the alimentary canal is thrown into tortuous folds. Two of these retractor muscles may be seen,

one, *f*, arising from the lower part of the tube, and inserted into the upper part of the gullet; the other *g*, into the bottom of the stomach. But besides these muscles, there is a set connected with the tentacular apparatus, for closing them up; in order, however, to understand how this is effected, we must attend more minutely to the cell itself.

The cell may be divided into three portions:—1. A basal, horny, transparent portion, firm and unyielding. 2. A soft, flexible continuation; and, 3. A marginal circle of bristle-shaped appendages, connected, like the rays on the fins of a fish, by a most delicate tissue.

When the animal withdraws itself, the arms are first folded up into a close bundle, and then retracted; the gullet being drawn down at the same time. With the descent of the œsophagus the soft part of the tube begins to be inverted, and the *setæ*, or bristles, gradually close together. These are then drawn inwards till they disappear, the soft tubular part forming a sheath around them, the whole constituting a sort of stopper, shutting up the animal in its horny case. The muscles by which this retraction of the tentacles is effected, are six in number; they arise from the horny part of the shell, and are inserted into its flexible portion, on which they act.

How marvellous are the facts on which we are dwelling! Well may they lead us to say with Fenelon:—"O my God, he who does not see thee

in thy works, has seen nothing! He who does not confess thy hand in the beautiful productions of this well-ordered world, is a stranger to the best affections of the heart. He exists as though he existed not; and his life is no more than a dream."

CHAPTER VIII.

CORALS AND MADREPORES.

At various depths of the ocean, objects are often observed of great interest and beauty. To quote an old poet, Du Bartas:—

> "Seas have,
> As well as earth, vines, roses, nettles, melons,
> Mushrooms, pinks, gilliflowers, and many millions
> Of other plants more rare and strange than these,
> As very fishes living in the seas."

Southey, in closing his wild description of Thalaba, says:—

> "Meantime with fuller reach and stronger swell
> Wave after wave advanced:
> Each following billow lifted the last foam
> That trembled on the sand with rainbow hues;
> The living flower, that rooted to the rock
> Late from the thinner element
> Shrunk down within its purple stem to sleep,
> Now feels the water, and again
> Awakening, blossoms out
> All its green anther-necks."

"There are few things." says captain Basil Hall, when in the West Indies, "more beautiful to look upon than the corallines, when viewed through two or three fathoms of clear still water. It is hardly an exaggeration to assert, that the colours of the

rainbow are put to shame on a bright sunny day, by what meets the view on looking into the sea in these fairy regions."

On another occasion, lieutenant Wellsted says:—"Through the bright blue and pellucid water, we could discern the minutest objects at an immense depth, and the secrets of the deep, thus laid open to us, afforded us the most magnificent spectacle that could be conceived; although there were neither

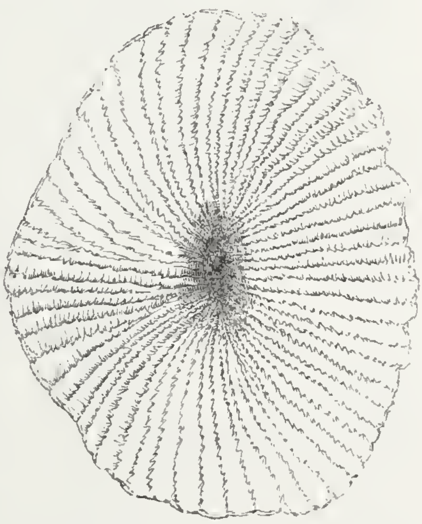
> 'Wedges of gold, vast anchors, heaps of pearls,
> Nor other treasures of the vasty deep.'"

Ehrenberg was so much struck by the corals in the Red Sea, that he exclaimed with enthusiasm, "Where is the paradise of flowers that can rival in variety and beauty these living wonders of the ocean?"

The growing coral field is singularly attractive. Such a combination of two terms, indeed, the one calling up the idea of inorganic, and the other of organic matter—all the difference, in fact, between a stone and a vegetable—may appear strange; yet, on due consideration, the junction of the two will be found not only warrantable, but appropriate. For in the depths of the ocean, trees, shrubs, and other plants of various kinds, not merely of horny, but calcareous substance, grow mingled together, like the plants of the land, and often in the richest profusion. Nor is this similarity confined to general form; for the coral-making polyps are flowers both

in figure and beauty of colouring. Like the aster or the pink, they have a bulbous star-like disc; and though some are minute, others vary in size from half an inch to two inches in diameter.

It will be well, however, here to notice an animal, which is a kind of borderer on the coral race. Let a polyp be supposed to deposit *within itself* a calcareous or earthy secretion, to form a rude skeleton or internal support, and to which a sort of skin will be formed of the gelatine, and we have before us the Sea Mushroom. The calcareous axis of these animals, from the Southern Ocean, is circular, or oval, formed of thin vertical plates, radiating from a common centre. Over the whole of this is spread the living gelatine, which dips into the intervals between every plate, and covers these also. The mouth is oval, and placed in the centre of the disc, surrounded with tubercles; and over the whole of the upper surface are distributed hollow tentacles, or arms not unlike a number of minute leeches, which seize and direct to the mouth the minute animals on which this polyp feeds. When these animals are roughly touched, or irritated, the arms are withdrawn between the thin plates, and the flesh shrinks

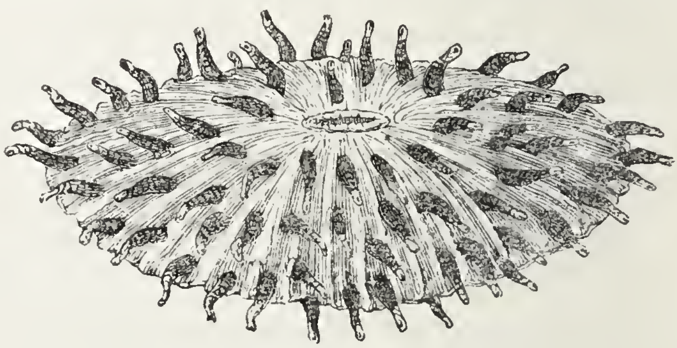


UPPER SURFACE OF THE SEA MUSHROOM.—FUNGIA ACTINIFORMIS.

down and accumulates in their interstices. Being free, they merely repose on the sand at the bottom of the water. Their power of locomotion is very limited.

The sea mushroom might, however, be easily supposed liable to danger: a violent agitation of the water, for example, might reverse it, and how then, it might be asked, shall it regain its position? The Creator has provided for the well-being of this, as well as every other creature. The living jelly that covers its surface, is so endowed as to secrete within its substance little bubbles of air; these act as floats, and thus the lighter side is kept uppermost on the waters.

In the animal just referred to, we observe a single polyp covered with gelatine, but in other instances a gelatinous expansion appears common to many associated polyps. The difference is here apparent between a house with a solitary inhabitant, and a large number of persons dwelling under the same roof, which the engraving will illustrate. A similar

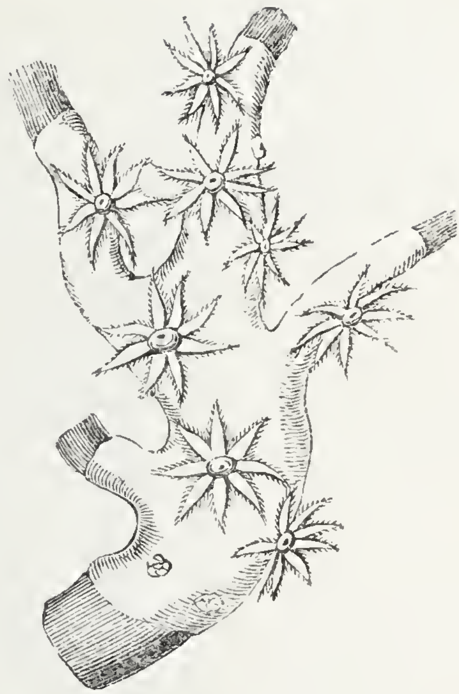


SPECIES OF MADREPORE.

instance appears in the red coral of commerce: it is a branching calcareous tree, secreted by the gelatine, which spreads round it like a rind; while the various

polyps, which make it their common dwelling, come forth at pleasure, like so many flowers.

The shortness and hardness of coral is well known, and its consequent adaptation to bear the action of the water. But other instances appear in which branches, secreted by a similar process, are of considerable length, and would thus be liable to be easily broken. Here then we



THE RED CORAL.

GORGONIA PUSTULOSA.

Two branches showing the gelatinous covering; in the third, the flexible horny stems appear.

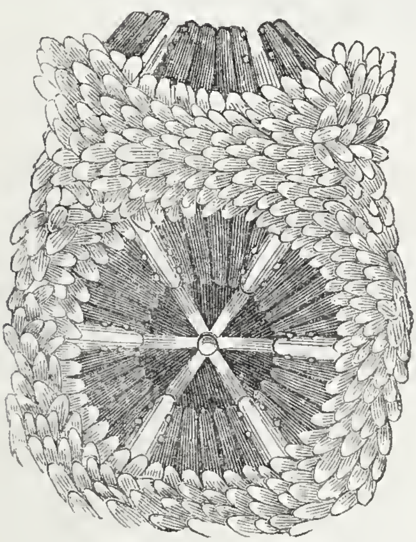
discover a special provision: for the stem instead of being hard, resembles horn, and is more or less flexible; or is composed of flexible, horny matter, with calcareous knots, placed at regular intervals. How obvious here is all-wise design!

ISIS HIPPURIS.

In which may be observed the living gelatine with its polyps, and the intermixture of horny and calcareous matter in the stem.

If the branching stems of a madrepore be examined, the unassisted eye may observe multitudes of minute cavities on its surface. But let the microscope be employed, and each of these cavities proves to be a beautifully constructed cell, remarkable for the exquisite precision of its form, as the engraving will demonstrate.

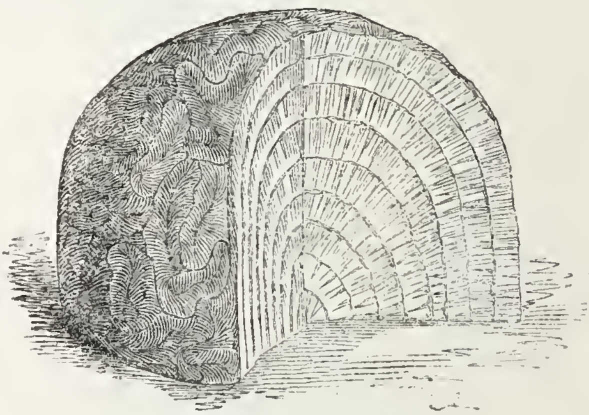
FRAGMENT OF MADREPORE.



CELL OF THE MADREPORE.

In the living madrepore, every part of the surface of each stem is covered over with a living gelatine, furnished with millions of minute polyps that issue from the multitudes of cavities observable on the surface of that substance. The following engraving illus-

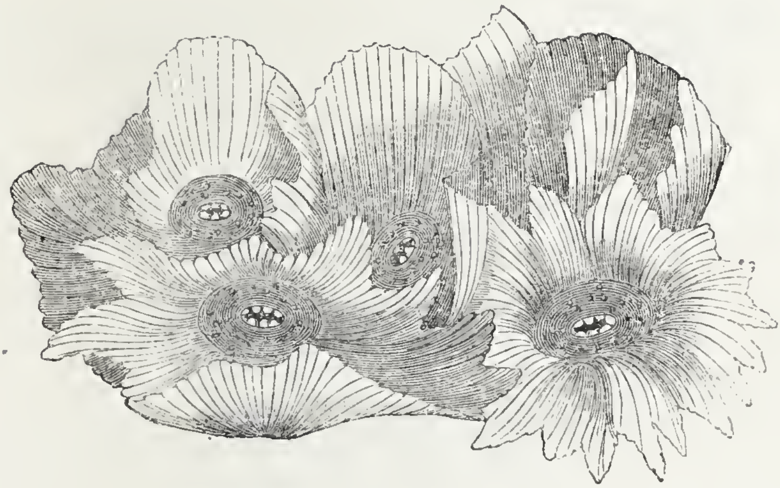
trates the structure of the *brain-stone*, so called from its outer surface resembling in its convolutions that essential part of the human economy. Of the process of forming this curious mass, a clear and correct idea



SECTION OF MADREPORE.

may easily be entertained. As in the sponge already described, the surface of the mass, and, of course, all its sinuosities, were covered with a living gelatinous film. When first deposited on the rock, a minute nucleus was only thus covered; but, as the creature grew, it went on building from its little centre, depositing one stony particle after another, and that as regularly and accurately as if it worked by compasses and rule, until it attained the diameter of one, two, or perhaps three feet. What wondrous power has God conferred on the delicate tissue that produces such fabrics!

But other marvels demand our attention. The *Pavonia lactuca*, from the shores of the South Sea



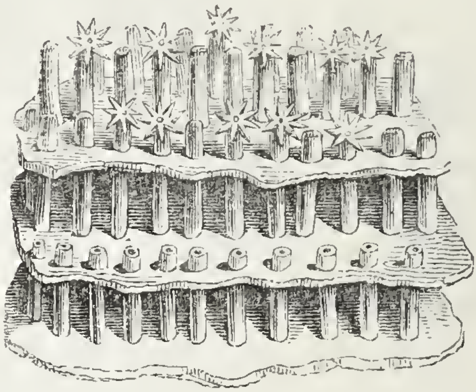
PAVONIA LACTUCA.

Islands is distinguished by the beautiful foliated expansions of the calcareous axis, resembling a cluster of cuplike flowers: each cup contains a polyp.

In the genus *Astræa*, the polyps are situated in deep polygonal laminated cells, and are connected by a thin gelatinous expansion covering the dark calcareous mass, which is generally of a convex or rounded form, externally. When the polyps of the *Astræa viridis* protrude themselves, and expand their numerous arms, consisting of a large and small one alternately, they resemble beautiful green flowers with a blue centre, the oral disc being tinted with the latter colour.

In other instances we observe a collection of tubes into bundles, like reeds bound together, and open at one end, through which the polyps protrude,

and into which they can retire. So it is with the group represented below. One example is a native



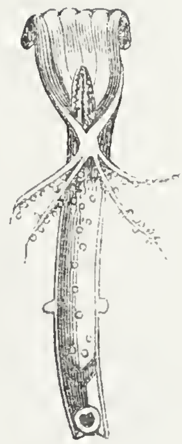
TUBIPORA, WITH POLYPS ISSUING FROM SOME OF THE TUBES.

of the Indian seas, the beautiful *Tubipora musica*, deriving its name from its resemblance to a cluster of organ pipes in miniature.

Though the fine red tubes of this zoophyte are compacted together, often closely, and secured by transverse floors or stages whereon one set of pipes open above another, the animals inhabiting them appear to be distinct from each other; that is, they are not vitally united, but merely build up a sort of town, the result of their combined labours, each constructing its own domicile.

In this case, each polyp is a crimson tube, while the arms are of pure green. When retracted, they are closely folded like the bud of a flower, as the engraving will show, and lodged, as is also apparent, within the folds of a membrane continuous with the margin of the tube. Thus the mechanism is

provided for the movements of the little polyp. As the membrane is placed all round the base of the animal, its contraction brings the polyp towards the opening of the cell, while it is retracted by the contrary action. The minute globules, which appear like strings of beads, are the germs of a future race. How often, in our study of the natural world, may we be reminded of the poet's words:—



POLYP OF A TUBIPORA.

> "In human works, though labour'd on with pain,
> A thousand movements scarce one purpose gain;
> In God's, one single can its end produce,
> Yet serves to second too some other use."

And thus it is not enough that the membrane of this minute polyp should enable it to rise or to descend by a beautifully simple mechanism; for it extends to where the earthy matter bounds the residence of the animal. Indeed, the calcareous tube, which is its dwelling, is produced by a gradual petrifaction of the membrane itself as it rises; for when it attains a certain elevation, its funnel-shaped edge expands horizontally, and, doubling itself, forms, by depositing calcareous particles in its substance, a stage composed of two plates soldered together! As, too, all the polyps act simultaneously in the same manner, and upon the same plane, the stages are produced which bind the bundles together; for the

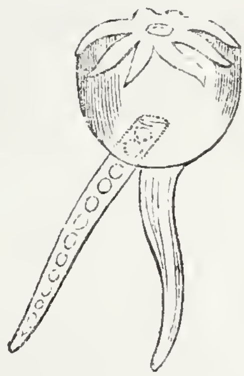
margins of the extended membrane of each polyp meet and coalesce. This being effected, the polyp increases, and the lining tissue rising, continues the cone-like orifice of the tube. From the base of the arms extend eight filaments, running through the tube, and attached to its lining membrane. On these the germs of the future race are attached by a neck or stalk, like minute eggs. How they are expelled, whether during the polyp's life or not, and how they cluster together and form bundles of pipes upon the old ones, or in new situations, are points utterly unknown. The limestone rocks of Derbyshire abound with fossils of this creature.

ALCYONIUM WITH POLYPS.

Distinct from the polyps now considered are those in which a tough body, often with calcareous

spicula like those of some sponges, interspersed through it and containing numerous canals, is studded with polyps like hydras. These are all seated in little cells on the surface, from which they can protrude and expand their arms.

The different species assume a variety of forms; all of which, however, are fixed on other substances, as stones and shells. The upper surface is dotted with cells, in which the polyps reside; and when they are all protruded, they cover the common pulpy mass with clusters of flowers, or stars. From the cavity of the stomach of each polyp of *Cydonium*—of which a single one is here represented, removed from the mass and magnified—a tube is extended, conveying nutriment to the general mass; a tubular filament also opens into the stomach, which contains the germs of a future progeny. When mature, they pass from the tube into the digestive cavity of the parent polyp, and thence through the mouth into the sea.

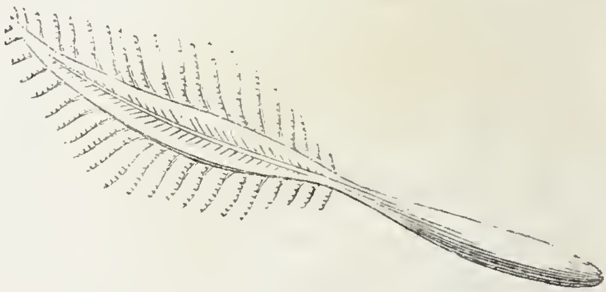


POLYP OF THE CYDONIUM.

Though these polyps and the general mass participate in one common life, as far as nutrition is concerned, yet there appears to be no community of feeling between them, for they expand and contract independently of each other. When one is rudely touched, it withdraws itself; but the rest remain unaffected. Local injury on one portion of the

general mass, seems to be unperceived, or unfelt at a remote portion; but a general shock being given, the whole mass, and the polyps, contract together.

Cuvier regards the sea-pens as forming a distinct section, and terms them swimming, or detached polyps.



A SEA PEN.—PENNATULA.

These animals, however, have a calcareous axis, though not fixed. Their name is derived from their resemblance to a quill feather, a double set of branches, occupying both sides of a shaft. Each branch is furnished with a row of polyps, resembling the barbules along the filaments, or barbs, composing the vane of a quill.

POLYPS OF A BARB OF THE SEA-PEN.

Almost endless is the variety of form which the fixed zoophytes exhibit, in the warmer latitudes of the ocean; affording abundant employment for the

philosophic investigator of nature. He beholds them like submarine forests, stretching out their branches in strange contortions—but all motionless; he sees them resembling waving plumes, fans of network, in clustered masses, gemmed as if with flowers of richest tints; or forming sea caves, on which the blue water sleeps tranquilly. Nor are they excluded from among the materials which man applies to common purposes. At Djeddah, in Arabia, and on many other parts of the coast of the Red Sea, the houses are constructed with blocks of beautiful madrepore. In the Indian isles, as well as in those of the Eastern Ocean, madrepores are used for the manufacture of lime. At Martinique, men drag them for that purpose from the bottom of the sea.

> "There, too, we see the living pile ascend
> The mausoleum of its architects,
> Still dying upwards as their labours closed;
> Slime the material,—but the slime was turn'd
> To adamant by their petrific touch;
> Frail were their frames, ephemeral their lives,
> Their masonry imperishable. All
> Life's needful functions, food, exertion, rest,
> By nice economy of Providence,
> Were overruled to carry on the process,
> Which out of water brought forth solid rock."

"To get an idea of the nature and structure of an individual coral reef," says Mr. Jukes, "let the reader fancy to himself a great submarine mound of rock, composed of the fragments and detritus of corals and shells, compacted together into a soft,

spongy sort of stone. The greater part of the surface of this mound is quite flat, and near the level of low water. At its edges it commonly slopes gradually down to a depth of two, three, or four fathoms, and then pitches suddenly with a very rapid slope into deep water, twenty, or two hundred fathoms as the case may be. The surface of the reef when exposed, looks like a great flat of sandstone, with a few loose slabs lying about, or here and there an accumulation of dead, broken coral branches, or a bank of dazzling white sand. It is, however, chequered with holes and hollows more or less deep, in which small living corals are growing, or has, perhaps, a large portion always covered with two or three feet of water; and here are fields of corals, either clumps of branching madrepores, or round stools and blocks of meandrina and astræa, both dead and living.

"Proceeding from this central flat towards the ridge, living corals become more and more abundant; as we get towards the windward side, we encounter the surf of the breakers long before we can reach the extreme verge of the reef; and among these breakers we see immense blocks, often two or three yards or more in diameter, lying loose upon the reef. If we approach the lee edge of the reef, we find it covered with living corals, commonly meandrina, astræa, and madrepore, in about equal abundance, all glowing with rich colours, bristling with branches, or studded with great knobs and blocks.

Where the slope is gentle, the great groups of living corals and intervening spaces of white sand can be still discerned through the clear water to a depth of forty or fifty feet, beyond which the water recovers its usual deep blue. A coral reef, therefore, is a mass of inert matter, living only at its outer surface, and chiefly on its lateral slopes."

The quotation just made, may present less of the picturesque than the reader might expect from preceding statements; but it will not be so with the following:—

"In a small bight of the inner edge was a sheltered nook, where the extreme slope was well exposed, and where every coral was in full life and luxuriance. Smooth round masses of meandrina and astræa were contrasted with delicate leaf-like and cup-shaped expansions of explanaria, and with an infinite variety of branching madreporæ and serintoporæ; some with mere finger-shaped projections, others with large branching stems, and others again exhibiting an elegant assemblage of interlacing twigs, of the most delicate and exquisite workmanship. Their colours were unrivalled—vivid greens contrasted with more sober browns and yellows, mingled with rich shades of purple, from pale pink to deep blue; bright red, yellow, and peach-covered nulliporæ clothed the masses that were dead, mingled with pearly flakes of escara and retepora, the latter looking like lacework in ivory. In among the branches of the corals, like birds among trees,

floated beautiful fish, radiant with metallic greens or crimsons, or fantastically banded with black and yellow stripes. Patches of clear white sand were seen here and there for the floor, with dark hollows and recesses beneath overhanging ledges. All these, seen through the clear crystal water, the ripple of which gave motion and a quick play of light and shadow to the whole, formed a scene of the rarest beauty, and left nothing to be desired by the eye, either in elegance of form or brilliancy and harmony of colouring." Such is the wonderful masonry of polyps.

> "Sight could not trace their evanescent changes,
> Nor comprehend their motions; till minute
> And curious observation caught the clue
> To this live labyrinth, where every one,
> By instinct taught, perform'd its little task,—
> To build its dwelling and its sepulchre
> From its own essence exquisitely modell'd;
> There breed and die, and leave a progeny
> Still multiplied beyond the reach of numbers,
> To frame new cells and tombs: then breed and die,
> As all their ancestors had done, and rest
> Hermetically sealed, each on its shrine
> A statue in this temple of oblivion!
> Millions of millions, thus from age to age,
> With simplest skill and toil unweariable,
> No moment and no movement unimproved.
> Laid line on line, on terrace terrace spread,
> To swell the heightening, brightening, gradual mount
> By marvellous structure, climbing towards the day.
> Each wrought alone, yet all together wrought,
> Unconscious, not unworthy, instruments
> By which a Hand invisible was rearing
> A new creation in the secret deep.'

An idea may be formed of the important part that these little animals play in the economy of nature by a contemplation of the vast extent of the coral reefs of the Pacific; some of which are a thousand miles in length, and several hundred in breadth. Thus we see a work of greater magnitude and stability than any of the works of man, produced by a vast number of animals, the individuals of which, seem at first sight to be powerless, fragile, and destructible.

In like manner, slowly and silently, millions of tiny arms, the members of a compound whole, ply the task, generation after generation, till the calcareous fabric, based on some submarine volcanic hill, rises to the surface, and there appears,

> "A coral island, stretching east and west,
> In God's own language to its parent saying,
> Thus far, nor farther shalt thou go, and here
> Shall thy proud waves be stayed!"

These islands are situated in the most exposed parts of the ocean, and are therefore subject to constant wear from the breaking of the waves on their sides. It would clearly be impossible for the hardest rock to stand out for many years against so continual and active an assault. But these islands owe their existence to the energy of the polyps which are unceasingly repairing the waste caused by the action of the sea, and hence the masonry stands and triumphs even over the waves of the ocean.

Here the sea birds repair, and uninterrupted,

save by the noise of the tempest-tossed billows around, rear their broods for many a returning season. Here the waves and winds carry seeds, and throw them on the coral; they germinate, the vegetation decays, and in process of time a rich mould is produced. Soon the cocoa waves its graceful head, and forests rise. At length, by chance as he would term it, but as we should say, according to the determination of Almighty Wisdom, comes man, and claims it as his own. Such is many a South Sea Island—such its origin, such its founders, while as the traveller recalls it, he perhaps adds,—

> "A sea-lake rose amidst the fossil isle,
> Reflecting in its ring its cliffs and caverns,
> With heaven itself seen like a lake below."

CHAPTER IX.

ANIMALCULES.

An amazing spectacle is presented when an assemblage of dissimilar forms is seen in one drop of water in which there is any decomposing animal or vegetable matter. They are from $\frac{1}{96}$ to $\frac{1}{2000}$ part of a line in diameter, and are often so crowded together that the intervals between them are still more minute than themselves. Yet some move with arrow-like rapidity, almost eluding the detection of the eye; while others "drag their slow length along," like the leech. Some revolve quickly, as if a portion of their body served as a pivot, a contrast to others apparently quiet or torpid. A series of gentle undulations secures the movements of some animalcules, but others give themselves to leapings of an inconsiderable extent. Amid their diversified gambols, however, all have the power of avoiding obstacles in their course, and their neighbours, who are in such close proximity.

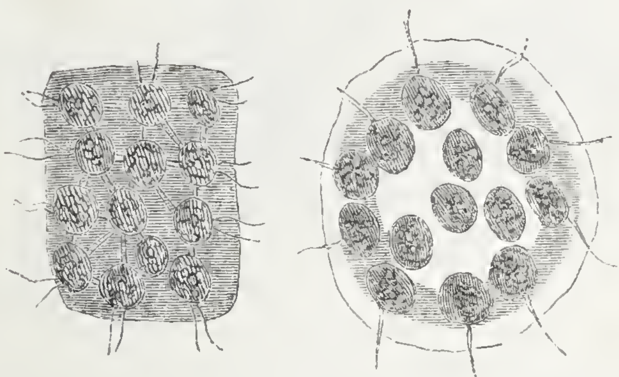
Some species of animalcules are far more common than others: but the rarer kinds may generally be procured by steeping dried grass, or leaves, particularly sage leaves, in a vessel of water, and

leaving it for a few days exposed to the influence of the sun and air, when the infusion will be found swarming with animalcules. A drop of this infusion, or of water from any pond or ditch, if put upon a thin slip of glass, made for the purpose, and viewed through a good microscope, will then present an astonishing spectacle. A little practice in the management of the instrument, and also of the eye, is necessary; for experience greatly improves the eye in the use of the microscope. It is important to observe, that as these creatures were first discoved in infusions, and were supposed to be restricted to them, they were primarily denominated *Infusoria.*

Some microscopic animalcules are termed *Polygastrica*, from their being supposed to possess a number of internal sacs, generally regarded as stomachs, and which are easily seen through the transparent covering of the animals, when viewed under a powerful microscope. No nervous filaments are discernible in their composition; nor any brain or central mass to which the impressions received from external agents can be transmitted. It is supposed that the nervous matter, instead of ramifying like threads through the system, is diffused universally throughout their composition, and is blended with it; but this theory is not positively proved, although probability favours it. Still, each one is fully prepared to enjoy existence. So far from forming a solitary class, twenty-six species of

the monad, the simplest of animalcules, are already known. The only locómotive organ hitherto discovered is a proboscis issuing from near the mouth; the vibratory or rotatory motions of which give it the appearance of numerous cilia.

The characteristic of another species is a minute red eye-like speck, situated within the creature, at the anterior part of the body, which is considered to be a rudimentary visual organ. And a minute and careful inspection of these living atoms, proves that they have a sensitive organization as conformable to their particular uses, and as well adapted to the wants and comforts of these microscopic beings, as the largest fish. One family of these creatures is provided with a distinct, gelatinous, membranous,



GONIA.

or shell-like substance, termed a lorica, in which they are more or less inclosed. This covering appears in different forms; sometimes as an open

shield, at others of a closed box or a pitcher, approaching the shell of the oyster or mussel.

The breast-plate *Gonium* is, in fact, a cluster of animalcules, consisting of sixteen spherical bodies, inclosed within a transparent shell, and dispersed regularly in a quadrangular form, like the jewels in the breastplate of the Jewish high priest. Sometimes the cluster appears irregular; this happens when the larger animalcules have arrived at maturity, and some of them are separated from the cluster. They are of a beautiful transparent green colour.

All the polygastric animalcules have been divided

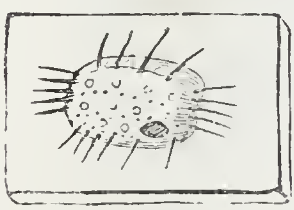
PROTEUS. AMOEBA.

into two primary groups: the *loricated*, or shell-covered, and the soft, or shell-less class. Some animalcules, as the *Proteus* (*amoeba*), belonging to the shell-less group, form for themselves locomotive

organs at pleasure, and are thus perpetually exhibiting changes of figure. These temporary oars are produced by the animal shooting out finger-like appendages, from different parts of its semi-fluid body, which are retracted, or which sink down at will, others being again protruded, as in the engraving on the preceding page.

Ehrenberg describes the organ of locomotion of another animalcule as a fleshy, undivided, sole-like foot, proceeding from the central opening, and resembling the part by which snails move from spot to spot. Nor does it allow the creature merely to creep; for by this means the animalcule when at rest can draw objects to it, and push away things by it.

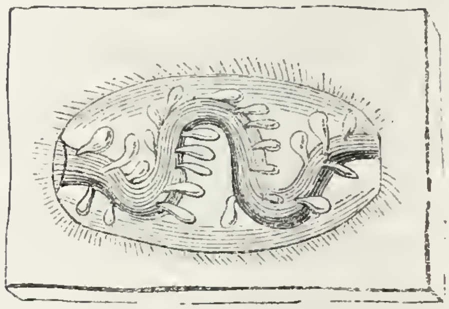
Some of these animalcules, again, are furnished with jointed bristle-like appendages, which are movable, and by their action propel them along; in addition, some have little hooks, which enable them to stick to other bodies, as in the annexed engraving.



EUPLŒA CHARON.

Others again, and by far the most numerous, have vibratory cilia, as locomotive organs, either disposed on parts of the body, or distributed universally over its surface; their action is supposed to be circular, or in other words, they are believed to sweep round and round, and they produce a tremulous and very perceptible current in the con-

tiguous fluid, as they thus propel the body onwards. In some species, as the *Paramecium aurelia* and others, these cilia are regularly arranged, so as to encircle the body; but in most, they only encircle the mouth, or are ranged in its vicinity. Besides acting as organs of locomotion, they are agents in the acquisition of food; they produce by their incessant vibration a current in the water converging to the mouth, and hurrying along with it either smaller animalcules or minute portions of vegetable matter, on which they feed, and which, but for this singular provision, they could not otherwise obtain.



PARAMECIUM AURELIA.

The mouth of the polygastric animalcules is generally found to be a simple dilatable and contractile orifice; but in some species, it appears under the form of a small projecting beak, or rather tube, composed of numerous teeth of an elongated shape, and calculated both for the prehension of food, and for bruising it previously to its being

CILIA OF THE VORTICELLA.

swallowed. In these species, the mouth does not appear to be surrounded with cilia, which would be unnecessary, but which, when the mouth is a simple orifice, are required for the direction of the food to it. The proboscis of some animalcules is situated, as we have seen, at the anterior extremity of these microscopic beings: this portion, Ehrenberg says, is cleft so as to represent a two-lipped mouth; the upper lip, bearing the proboscis, being very readily distinguished.

The term polygastrica, by which the present group is distinguished, refers to the supposed complexity of the digestive apparatus, which is stated to consist of a number of internal sacs, or stomachs; in some, arising from the mouth itself by separate tubes, in others, appended to a kind of intestinal canal, which traverses the body, and terminates either at the extremity of the body, opposite to the mouth, as in *Paramecium aurelia*, or which, winding up, terminates in a depression near the mouth, as in *vorticella.*

The sacs, though distinguishable in the animals under ordinary circumstances, are rendered more conspicuous when the animals have swallowed water in which colouring matter is suspended, in a state of very minute division, but not chemically dissolved. Trembley, in his investigation of the structure of the hydra, adopted this method, and Gleicher attempted it, though unsuccessfully, in his investigations as to these animalcules. The fact is,

that many of our metallic or earthy colouring materials immediately poison these creatures, when of course, the experiment fails. Ehrenberg tried in vain with the indigo and gum-lac of commerce, these substances being always contaminated with a slight admixture of white lead, which acts as an instantaneous poison; but with pure indigo, or pure carmine, the experiments were successful.

When a minute portion of a very weak solution of indigo is added to a drop of water containing *vorticella*, an animated scene ensues. Eager for the food, which they swallow with avidity, they throw the cilia into rapid action, producing currents in the water, hurrying with them the particles of the indigo in gyrations converging to the mouth. In a short time, a number of dark blue circular dots begin to show themselves on the transparent body of the animalcule, which are occasioned by the particles of the indigo accumulated in these situations; they also make manifest the intestinal tube, and their progress can be gradually traced through its extent. It is thus by a series of experiments that Ehrenberg was at length enabled to determine the number of the sacs, or stomachs, and the course of the intestinal tube. But it appears that all the sacs are not filled at the same time; many continue long without receiving any particles of colouring matter, and the whole range of the alimentary tube is not simultaneously tinted. The number of sacs thus distinguished, amounts to two

hundred in some species; in others, they are less numerous.

It is on the characters and positions of these sacs, and on the course of the presumed intestinal tube that Ehrenberg has founded the divisions of this class; but professor Jones, while he acknowledges that the views of this naturalist are sanctioned by, general consent, is not disposed to admit their accuracy in all respects, and states that his own observations (made by means of a compound achromatic microscope, and employing powers nine-tenths, one-half, one-fourth, and one-eighth of an inch focus) have led to very different conclusions. The positions of the orifices for the reception and rejection of aliment he found to be such as Ehrenberg has indicated; but the most patient investigation did not enable him to detect the arrangement of the tube, and the sacs appended to it, as figured and described by that author. He states that he has never been able to perceive, when one of the carnivorous animalcules has swallowed another, that it has been conveyed, as was to be expected, into one of these so-called stomachs, but that he has traced it into "what seemed a cavity excavated in the general parenchyma of the body."

In the next place, he states that these sacs have no appearance of being attached to any tube by means of penducles, or necks; and that in *paramecium aurelia*, so far from appearing to be connected with a central canal, as is represented by Ehrenberg,

they are in continual circulation, moving up one side of the body and down the other, and even changing their relative positions, like the coloured granules visible in the gelatinous substance of the hydra. And, thirdly, he affirms that in no instance has he been able to detect a central tube at all, as depicted by Ehrenberg, much less the branches leading from it to the sacs; and he adds, that the circumstances attending the prehension of food, would, in themselves, lead us to imagine a structure different from that described by Ehrenberg.

He adduces, by way of confirming his views, the changes of form which these animalcules undergo, when devouring prey nearly equal to themselves in bulk, and therefore incapable of entering into one of these sacs; the mouth dilates to engulph the victim, and when this is swallowed, the whole body, as in the hydra, becomes greatly extended. As an

THE FLASK ANIMALCULE.

example in point, professor Jones figures the flask animalcule* in its ordinary state; preparing to

* Enchelis pupa.

attack its prey; in the act of engulphing it, and with the prey wholly swallowed.*

When two highly intelligent and accurate observers are thus at issue, and when their respective investigations conduce to results so different, we must wait for further experiments. It is, however, remarkable, that in the hydra, the granules already referred to, which are certainly not stomachs, also become tinged with the juices of the prey on which the animal feeds, which juices, by some means unknown at present, they absorb, and thus charged, circulate through the gelatinous substance of the body.

There is no part of the history of these animalcules more calculated to excite astonishment than their mode of reproduction, so different from that of other races of beings; and what is still more surprising is, that the same individual, as it would appear, often reproduces in four different ways.

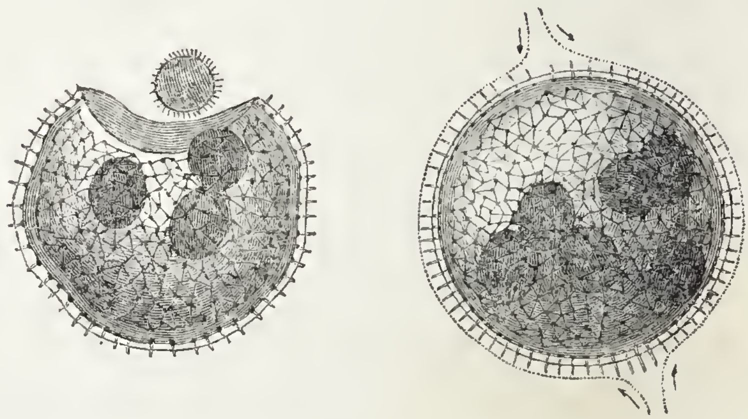
One mode of reproduction is by gemmules or buds, sprouting from the outer surface of the parent, as in the hydra. These little buds gradually assume their destined form, develop cilia, and become detached and independent, and in a short period afterwards attain

INCREASE BY BUDS.

* For other information on this doubtful point, respecting the structure of the digestive apparatus of the *Polygastrica*, see professor Jones's valuable work, entitled "A General Outline of the Animal Kingdom."

to their full growth, giving origin to buds themselves.

Another mode, which is seen in *Volvox globator*, is by minute globular bodies, of a dark green colour,



INCREASE OF THE VOLVOX GLOBATOR.

covered like the parent with vibratile cilia, and which swim about in the interior of the body of the parent, where they appear to have ample space. The transparency of this animalcule, which is of a globular figure, and of a delicate green, permits the germs it incloses to be readily seen.

Professor Ehrenberg observes: "All endeavours to acquire some knowledge of the organization of the genus *volvox* have proved only successful, now that observation has been, at last, directed to the right depth, (1833.) Formerly, the entire globule was generally regarded as a single verrucose or ciliated animalcule, and its bursting considered as the reproduction of single individuals. But this view leads to wonders and to contradictions: it is

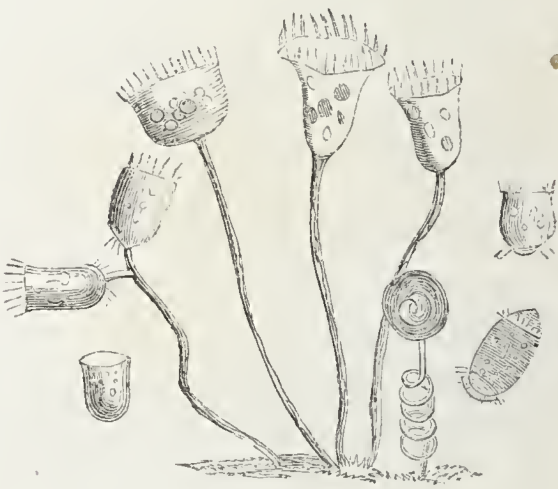
evidently erroneous, and the organic relations lie much deeper. Each globule is a hollow *monadier*, (monadenstock) of many hundreds, nay, thousands, of minute animalcules; to be readily seen. When they have attained a proper degree of development, the outer skin of the parent bursts, and they emerge from their imprisonment, to undergo a like destiny."

The most usual, and certainly the most extraordinary mode, by which new animalcules are produced, is by the division of the animalcule itself into two or more portions, each portion becoming a perfect being, and again dividing in turn. In animalcules of an elongated form, the division generally takes place longitudinally, each side becoming a distinct being, with all its organs complete; but in oval animalcules, the division is transverse, first beginning with a middle indentation, which increases till the separation is effected.

INCREASE OF THE MONAD.

Some animalcules increase both by gemmules and by division, as the *Convallaria*, but chiefly by the latter. This one resembles a bell-shaped flower, supported upon a slender footstalk, by which it is attached to fixed objects. This footstalk is highly contractile, and winds round in a spiral manner when the animal is alarmed, and thus withdraws it from danger. The division takes place only in the bell, which first increases in circumference, and begins

to divide at its margin, the fissure gradually extending to its base; when the fissure is complete, one-half is found perfect, and is destined to continue on the footstalk, and may, therefore, be regarded as the parent of the other; this is now attached by a slight connexion to the top of the footstalk by the side of the permanent bell, which is found to have cilia, not only at its upper margin, but also round its base. It now becomes detached, and loses the marginal cilia, retaining the basal ones; and thus it swims about; but it has not yet developed its footstalk; this it gradually puts forth, the adult stage is then acquired, and it becomes fixed to some foreign body, like the parent whence it sprung.

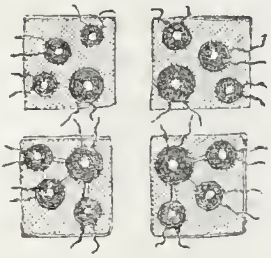


CONVALLARIA.

While in its free condition this animalcule assumes various modifications of form, and in these states has been described as so many distinct species; and it is by recent observations only that its real

character has become known. The foregoing sketch will illustrate the increase described, and also show the new animalcule, after gaining its freedom, in three different forms.

There is still another mode of reproduction by division: it occurs in animalcules which appear, as the *Gonium*, to consist of a number of globules (sixteen in one species), inclosed in a thin transparent envelop; the mass thus compounded divides in this species into four equal parts, each part containing one large and three smaller globules. After their separation from each other, these parts swim freely about in the water, and increase in the number of their constituent globules, to undergo a fresh division. In other species, the division is into still more numerous portions.



INCREASE OF THE GONIUM.

Some animalcules, it must be further remarked, increase by division, by gemmules, and by eggs or spawn. In the *Kolpoda cucullus*, Ehrenberg detected most satisfactorily the latter mode, and he describes the eggs, when excluded, as appearing in the form of a delicate mass resembling network.

No mode of reproduction, however, is more astonishing than that of division, none so productive. It is wonderful when we consider that each divided part has to assume all the organs of the perfect being; that these have therefore to become

developed, and to assume their due form and situation. And as to productiveness, the *Paramecium aurelia*, well supplied with food, has been observed to divide once in twenty-four hours, so that, as professor Jones observes, "in a fortnight, allowing the product of each division to multiply at the same rate, 16,384 animalcules would be produced from the same stock," and in four weeks, the astonishing number of 268,435,456 new and distinct beings.

The question arises, from this astounding increase—To what is it attributable? Various replies have been offered to it, but the only satisfactory one is, "from the air," in which the germs of these beings are borne hither and thither, and under certain circumstances become visible. The following experiments will leave the reader in no doubt on this point. A very intelligent and careful observer says, "I filled a glass flask half full of distilled water, in which I mixed various animal and vegetable substances; I then closed it with a good cork, through which I passed two glass tubes, bent at right angles, the whole being air-tight. It was next placed in a sand bath, and heated until the water boiled violently, and thus all parts had reached a temperature of 212° Fahrenheit. While the watery vapour was escaping by the glass tubes, I fastened at each end an apparatus, which chemists employ for collecting carbonic acid; that to the left was filled with concentrated sulphuric acid, and the other with a solution of potash. By means of the boiling heat,

everything living, and all germs in the flask or in the tubes were destroyed, and all access was cut off by the sulphuric acid on the one side, and by the potash on the other. I placed this easily moved apparatus before my window, where it was exposed to the action of light, and also, as I performed my experiments in the summer, to that of heat. At the same time, I placed near it an open vessel with the same substances that had been introduced into the flask, and also after having subjected them to a boiling temperature. In order now to renew constantly the air within the flask, I sucked with my mouth several times a day the open end of the apparatus filled with solution of potash, by which process the air entered my mouth from the flask through the caustic liquid, and the atmospheric air from without entered the flask through the sulphuric acid. The air was of course not altered in its composition by passing through the sulphuric acid into the flask, but if sufficient time was allowed for the passage, all the portions of living matter, or of matter capable of becoming animated, were taken up by the sulphuric acid and destroyed. From the 28th of May, until the early part of August, I continued uninterruptedly the renewal of the air into the flask, without being able, by the aid of the microscope, to perceive any living animal or vegetable substance, although during the whole of the time I made my observations almost daily on the edge of the liquid; and when at last I separated the dif-

ferent parts of the apparatus, I could not find in the whole liquid the slightest trace of *infusoria*, of *confervæ*, or of mould; but all the three presented themselves in great abundance a few days after I had left the flask standing open. The vessel which I placed near the apparatus contained on the following day vibriones and monads, to which were soon added larger polygastric *infusoria*, and afterwards *rotatoria*."

Like other animals, these microscopic beings obey fixed laws of geographical distribution, groups and species having assigned limits of habitation. They do not sleep, at least they have never been observed in a state which might be properly called one of repose. They are capable of a torpid existence in heart dried up by a summer sun; and they hibernate frozen in ice.

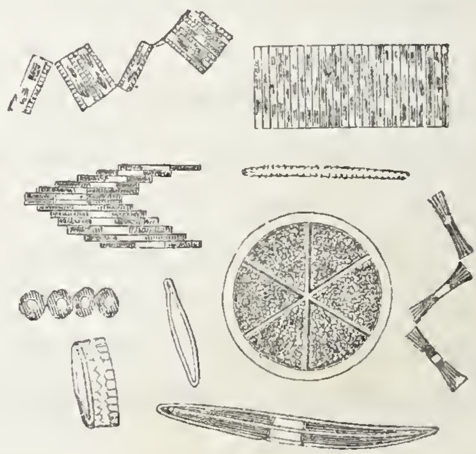
An interesting vegetable production, having a deceptive resemblance to white dressed glove-leather, has lately been found on a meadow above the wire factory at Schwartzenberg, in the Erzgebirge. A green slimy substance grew on the surface of the stagnant waters in the meadow; which, the water being slowly let off, deposited itself on the grass, dried, became quite colourless, and might then be removed in large pieces. The outside of this natural production resembles soft dressed glove-leather, or fine paper; is shining, smooth to the touch, and of the toughness of common unsized paper. On the inner side, which was in contact

with the water, it has a lively green colour, and green leaves are distinguishable which have formed the leather-like pellicle. Ehrenberg has submitted this meadow leather to a microscopic examination, and has found it to consist most distinctly of *confervæ*, forming together a compact felt, bleached by the sun on the upper surface, and including some fallen tree leaves and some blades of grass. Among these *conferva* lie scattered a number of siliceous *infusoria*, including sixteen different sorts, belonging to six genera; besides three sorts of *infusoria* with membranous shields, and dried specimens of another kind.

Ehrenberg submitted, a few years ago, to the Academy of Sciences of Berlin, a foot and a half square of natural wadding or flannel, consisting of *infusoria* and *conferva*, which was found to the extent of several hundred square feet, near Sabor, in Siberia, after an inundation. This substance is analogous to the "Meadow Leather," described already, but is far more surprising, from its occurrence in such an immense mass. The flannel is chiefly formed of unramified branches of *Conferva rivularis*, interwoven with fifteen species of *infusoria*.

On January 31, 1687, a great mass of paper-like black substance fell with a violent snow storm from the atmosphere, near the village of Raüden, in Courland. This meteoric substance, described completely and figured in 1686-1688, was recently considered

by M. Von Grotthus, after a chemical analysis, to be a meteoric mass; but M. Von Bergelius, who also analysed it, could not discover the nickel said to be contained in it; and Von Grotthus then revoked his opinion. It is mentioned in Chladni's work on Meteors, and appears as an aërophyte in Nees von Esenbeck's valuable Appendix to R. Brown's "*Botan. Schriften.*" Ehrenberg has examined this substance, some of which is contained in the Berlin Museum, (also in Chladni's collection,) microscopically. The whole has been found to consist evidently of a compactly matted mass of *confervæ*, and of about twenty-nine well preserved species of *infusoria*, of which three only are not mentioned in Ehrenberg's large work, although they have since occurred living,



FOSSIL ANIMALCULES.

near Berlin. Of the twenty-nine species of infusoria, only eight have siliceous shields, the others having those which are soft or membranous. These infusoria have now been preserved one hundred and

fifty-two years. The mass may have been raised by a storm from a Courland marsh, and merely carried away, but may also have come from a far distant district. The original locality of the substance appears to be neither the atmosphere, nor America; but most probably either East Russia or Courland.

In Sweden, on the shores of the lake Lettnaggsjon, near Urnea, a vast quantity of extremely fine matter is found, much resembling flour in appearance, and called by the natives, Mountain Meal.* It is used as food, being mixed up with flour, and is nutritive. This substance is ascertained, by examination with a microscope, to consist of nothing else than the shelly coverings of certain polygastric animalcules, which coverings, as the animals perish, accumulate from age to age at the bottom of the waters, and form a deep stratum; this drying on the shore, or in places no longer covered by the water as formerly, assumes the appearance whence it has its name, and each particle is the relic of a microscopic animal.

The marvellously rapid increase of these creatures gives rise to other extraordinary results. As from one individual, in four days, one hundred and forty millions of millions would have existed, so there is a sufficiency to form two solid cubic feet of siliceous rock. Most of the solid skeletons of polygastric animalcules are external siliceous covers, which envelop the entire body; they long resist decay, and exhibit the general form and character of the species

* Borgmehl.

to which they belonged. To them must be traced the polishing slate,* or tripoli of Bilin, so frequently used in some of the arts. The size of a single one of the *infusoria*, which forms this substance, amounts on an average, and in the greater part, to one two hundred and eighty-eighth of a line, which equals one-sixth of the thickness of the human hair, reckoning its average size at one forty-eighth of a line. The globule of the human blood, considered at one three-hundredth, is not much smaller. The blood globules of a frog are twice as large as one of these animalcules. As the slate of Bilin is without cavities, these animalcules lie closely compressed. In round numbers, about 23,000,000 of animals would make up a cubic line, and would in fact be contained in it. There are 1,728 cubic lines in a cubic inch; and therefore a cubic inch would contain, on an average, about 41,000,000,000 of these animals. On weighing a cubic inch of this mass, I found it, says an observer, to be about 220 grains. Of the 41,000,000,000 of animals, 187,000,000 go to a grain; or the siliceous shield of each animalcule weighs about one one hundred and eighty-seven millionth part of a grain.

The white calcareous earth, so common at the bottoms of bogs and morasses, has its origin in the ceaseless labours of some animalcules; and the "bog-iron ore" consists of the ferruginous shields of others. The chalk-beds of England are many

* Polirschiefer.

miles in extent, and many hundred feet thick; and these are also composed of the shells of infusorial animalcules. Many of the enormous beds of limestone with which we are familiar result also from the accumulation of countless millions of these minute beings. Swarming as they do, in salt and fresh waters, and secreting from the lime which is held there in solution the necessary materials for their shields and calcareous skeletons, they form in process of time, by their enormous aggregation, the vast piles compared with which the pyramids of Egypt shrink into abject insignificance. From the creature we turn again to the Creator, whose power is thus marvellously displayed. With Him, there is neither great nor little; his hand formed, and his eye sees, every minute animalcule, as well as all other living things; every atom of matter, as well as worlds, suns, or systems.

CHAPTER X.

PARASITIC ANIMALS.

The view already taken of the wide diffusion of animal existence, like a boundless prospect, almost overwhelms us. But here we must not stop, for not only may a single drop of water be a crowded city of habitation, but every blade of grass, every leaf, every flower, has its colony, and even the juices of plants and the fluids of animals are thronged with animalcules. Wherever life can exist, there has the Almighty destined it, under some form, to be. We look on with wondering admiration at myriads of beings, to whom a single drop of water offers "space and verge enough," but these prey on others smaller than themselves, and these again on others still more minute, till they cannot be detected by our most elaborate microscopes, and we are constrained to exclaim,—"Great are the mysteries of creation! How small a part of thy ways and thy works, eternal Creator, do we know!"

While, however, we find life diffused wherever organic forms can exist, and all precisely adapted to the place they occupy, the destined abode of some animals is in situations so peculiar, so unexpected, that their presence there naturally excites the greatest surprise, and the more we reflect on the

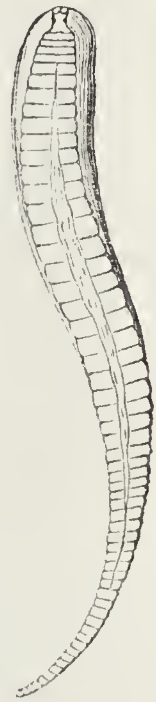
fact, the more mysterious does it appear. The localities thus occupied have led to many conjectures; and—How do they get there? has been often asked, but not often satisfactorily answered.

Certain it is, that they have been neither detected in the air, nor in the water; they are not known to exist on grasses or plants, nor on the surface of the ground beneath our feet; they are found exclusively in situations in which it is difficult to prove how they can have been deposited, yet it is here only, as far as our limited sphere of observation extends, that they are met with, and in no others. To what do we allude? To those extraordinary creatures which are only known as tenants of the living bodies of other animals, and of which some species are respectively abundant in the fluids of the system, while others occupy the alimentary canal, and others are imbedded in the muscles, the liver, and the brain. They are parasitic animals, and have received the general name of *Entozoa*, from two Greek words, within, and an animal, from the circumstances connected with their existence; but all do not belong to the same division of the animal kingdom. Some form part of the group* in which no nervous filaments have been discovered, while others are more highly organized.

The *Trichina spiralis* exists only in the muscular structure of the human subject; the *Linguatula* inhabits the hollows of the frontal bone, called frontal

* Acrita.

sinuses, of quadrupeds; certain hydatids are found in the brain, other species in the liver, and, it may be added, in the cellular tissues of the body, in the abdominal cavity, and even in the eyes themselves.



LINGUATULA.

Let us take, for example, one species of hydatid* which is common in the brains of sheep, and produces the most terrible ravages. How did this parasite become developed there? And when there, supposing it to produce others of its kind, how are they to get into the brains of other sheep? The sheep dies, and the hydatid in its brain also perishes; and as this is invariably the case, one might suppose that with the death of every sheep thus afflicted, the race of these hydatids would be extinguished, but it is not so; for it is calculated that out of every thousand sheep fifteen will die of this malady the first year of their age, five in the second year, two in the third, and one in the fourth, and so on, generation after generation. It is supposed that "nearly a million of sheep are destroyed every year by this pest of the ovine race" in France only.

Many have been the theories upon which it has been attempted to explain the origin of these and other *entozoa*, and to account for their presence in

* Cænurus cerebralis.

such unlooked-for situations; and one of the theories advocated by men of high attainments, is that of "equivocal or spontaneous generation;" in other words, that life is the result of certain combinations of matter—a most strange supposition; or that they are developed from atoms of matter collected together, which assume vitality and a definite form, as the ancients believed that bees were produced from the blood or flesh of slaughtered oxen, when undergoing the process of decomposition,* and that reptiles were formed from the mud of the river Nile, by the agency of the beams of the sun.

Such a theory is to cut and not untie the Gordian knot; it is unworthy of science; it is a blot on the page of truth. Great ignorance of the laws of nature may be pleaded as an excuse for the ancients, but in these days, when the light of science burns brightly, and old errors are effaced, it seems strange that men, calling themselves philosophers, should have recourse to such a system. Yet so it is. Among those who advocate the spontaneous generation of organic beings, is to be ranked Dr. Weissenborn, of Weimar, in Germany, who has recently published a paper on the spontaneous generation of certain plants, peculiar to snow, which he commences by observing that, "Although the recent discoveries of professor Ehrenberg appear little favourable to the casual production of organic beings at the present period, yet they do not in the least affect the

* Virgil, Georg. lib. iv. line 281, et seq.

theory, that their original existence is owing to a purely dynamic (self-potent) process. The importance of this subject will perhaps excuse me, if I try in this place to lessen the weight of the conclusion, that animalcules and other organic bodies are never the result of spontaneous generation,* by some reflections on certain spontaneous generations which are undoubtedly going on in our time, and which, in calling the attention of the reader to the traces of a nascent future creation, may serve to throw some light on the conditions of the former and present ones, as well as to banish the uncouth idea of a '*Deus ex machinâ*;' "†—the uncouth idea, this naturalist means, of inferring the existence of a God from works of consummate skill, from the exquisite mechanism of organic bodies!

But by what chain of reasoning does Dr. Weissenborn prove his theory? Positively, by no arguments at all. He assumes it, but assigns no reasons whatever. He finds certain plants in unexpected situations—that is, growing in snow—and he asserts that they are, therefore, to be ascribed to spontaneous generation. "For proofs of this new

* Professor Ehrenberg has succeeded in establishing two great natural laws:—1st. That the animal organization is perfect, in all its principal systems, to the extreme limit of vision assisted by the most powerful microscopes; 2ndly. That microscopic animalcules exercise a very great and direct influence on inorganic matter. From the first proposition is derived the conclusion, that no organic bodies can be by possibility their own authors.

† This refers to the custom of players introducing the gods on the stage of a theatre by means of a machine.

creation we have to look to the poles, and the tops of the Alpine mountains, where the geological formation of ice and snow has already fairly begun. The flora of these regions is as yet very poor, but we have to consider that it is in an incipient state. On the Alps grow two species, the red snow,* and a very curious production, which M. Hugi found only on the glacier of Unteraar, but which is said also to occur on that of Chamouni. To the snow flora of the poles, consisting likewise of the red snow, the expedition of the *Recherche* to Spitzbergen has lately added a second species of red snow, and a delicate green flabelliform plant, two inches in height.

"Now we have only to notice the peculiar circumstances under which these plants are found, in order to be convinced that they are the specific and spontaneous productions of a soil that is neither land nor sea, and to render it probable that from every new and well-established stratum there will spring a new creation at any time." So that because a living or organised structure appears in an unaccountable place, it must, therefore, be of spontaneous generation! Now, let us see what spontaneous generation involves. It supposes inert matter capable of endowing itself with life, or of becoming necessarily vitalized under certain conditions; next, it involves design in the form to be assumed, choice as to what organs shall develop

* Protococcus, or Palmella nivalis.

themselves, arrangement as to the places they shall occupy, contrivance as to their modification for certain predetermined offices,—and all proceeding from a "purely dynamic process!" Such beings, as Dr. Drummond well observes, "of the contrivance which they display, are themselves the contrivers, of the design—the designers." The same able writer says, it is to ignorance "that we are, I believe, to attribute this theory, whether it be applied to a fungus, or an animalcule, or an entozoon. We know not how a mucor originates on a decaying vegetable or animal matter, nor how millions of animalcules appear in a vegetable infusion, nor how an entozoon grows in the intestines or the brain of an animal; but because we do not in our present state of knowledge understand these things, are we to fall into the error of the ancients, and attempt to explain, by what seems next to an impossibility, their appearance on the supposition of a spontaneous generation? Some of these obscure animals have an organization so perfect and admirable, that it would seem to me almost as consonant to reason and sense to attribute the formation and economy of an elephant, or, I might say, man himself, to equivocal generation as theirs."

The thing contrived, we may add, can never be its own contriver; that which is not, cannot be, but by a pre-existing power, exerting wisdom and skill. The laws of life, and the continuance of species, are fixed and pre-appointed; nothing vital in the

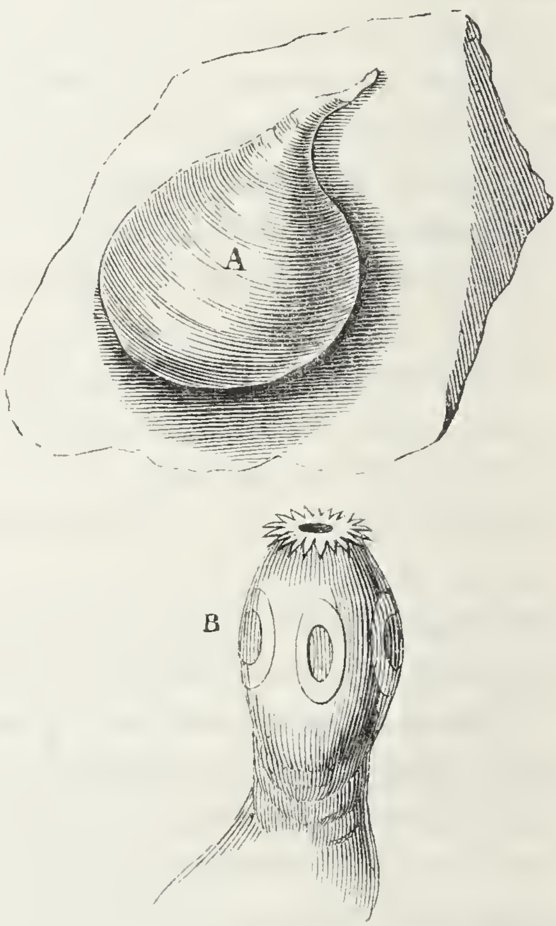
present state of our globe exists which has not a parent. The first parent did not come forth into life by any spontaneous or casual process, whereby inert matter became the designer of its own design; but was formed by the God of heaven and earth, whose wisdom and goodness are manifest in every structural part, in every action, in every instinct of every organised body, from man to the microscopic animalcule, from the cedar or the oak to the red snow plant of the polar regions. To attribute the existence, then, of the cerebral hydatid to spontaneous generation, is worse than folly; or rather, is the folly of the man who says in his heart, "There is no God."

Let us now proceed to the examination of these strange *entozoa*, and then endeavour to show how they may be, (we do not say, how they are,) deposited in the parts of the frame which they occupy.

The cerebral hydatid* appears like a globular membranous bag or cyst, filled with gelatinous fluid, and varies in size from that of a pea to that of a hen's egg. The membrane composing the cyst is transparent and delicately thin, but consists of two or three layers, of which one at least appears to be muscular, regular interlacing fibres being discernible in its structure, by means of a powerful microscope; and the hydatid, when removed and put into warm water, or when stimuli are applied,

* Cœnurus cerebralis.

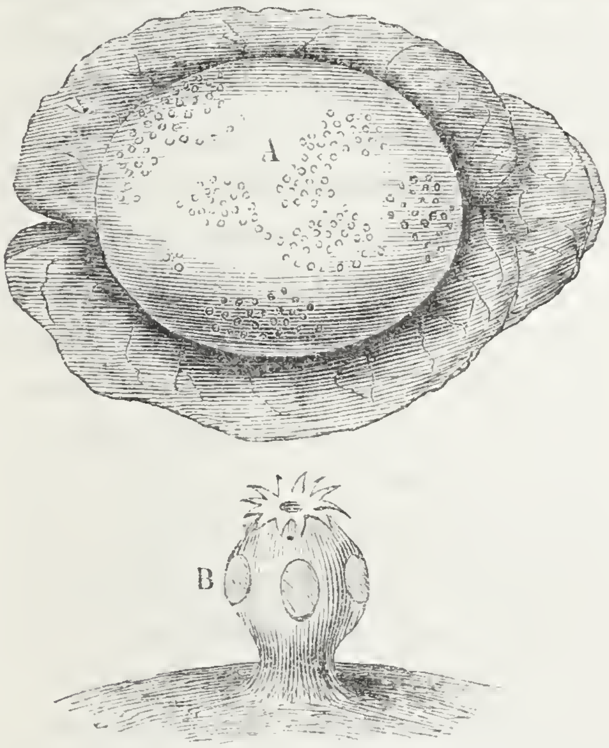
exhibits vibratory or contractile movements. This membranous cyst may be regarded as the body of the animal, and it is studded thickly but irregularly with numerous heads, or rather perhaps slightly elevated mouths, each being margined around with minute arms, and being also furnished with suckers,



COMMON HYDATID, A. MAGNIFIED HEAD, B.

calculated for attaching the mouths to the tissues of the part in which they are seated, and from which they imbibe their nourishment.

The following is a sketch of the cerebral hydatid, of the natural size, and is accompanied by a magnified representation of one of the heads. The common



CEREBRAL HYDATID, A. ONE OF THE HEADS MAGNIFIED. B.

hydatid,* which is found in the liver, the abdominal cavity, and in the cellular tissues of animals, agrees generally in its characters with the preceding; but it has only one head terminating a portion of the cyst, which appears as if drawn out like the neck of a Florence flask. It is furnished with suckers and the oval orifice is surrounded with arms.

The reproduction of these curious animals is

* Cisticurcus tenuicollis.

apparently by minute internal buds or gemmules, which grow on the membranous walls of the sac: on attaining to a certain size, they become detached, and may be seen by means of a lens, floating in the gelatinous fluid with which the sac is filled. According to the observations of Mr. Youatt, in allusion more particularly to the cerebral hydatid, when the fluid contained in the cyst is clear, the internal membrane will appear, if examined with a lens, to be covered with a countless multitude of little grain-like bodies, disposed in regular lines, and adhering by filmy particles. These he calls eggs. None, however, are discoverable in the fluid itself. But when the fluid is turbid, it will be found full of apparently fibrous particles, which when viewed through a microscope, are resolved into minute worms, many eggs being also intermingled: but when a still more turbid and opaque state of the fluid prevails, it is owing to an immense quantity of these worms, while all the eggs or granules have disappeared. "These worms," he says, "are about half a line in length; the head is in the form of a tetragon, (or four-sided figure,) with a circle of rays at its summit, and a mouth on each of the four sides; the neck is short, and the body covered with rings or wrinkles. They appear to swim with great velocity and to be possessed of much activity. They have also the peculiar property of issuing at pleasure from and of returning to the cyst which they inhabit. If the cyst be removed from the

brain, hundreds of them may be forced through the numerous heads of the hydatid by the slightest pressure; and at other times, when the cyst is examined, numbers of them will be found in or protruding from its various oval apertures."

Another curious fact may here be noticed. One of these hydatids is very often found to have its cysts filled with multitudes of perfect but small hydatids, of various sizes, to the amount of scores. Instances of this kind have frequently been observed; and Mr. Youatt gives one in which a hydatid larger than the egg of a goose, found in the abdominal cavity of a monkey, contained more than ten thousand minute but perfect cysts, together with a countless number of granules, which lined the membranous cyst of the parent hydatid, and which may be regarded as the germs of a future race.

Here, then, three questions present themselves: First, is it from these minute multitudinous granules that the worms in question spring? Secondly, are these worms hydatids in a larva or imperfect state? or, thirdly, are they themselves parasites of a parasite, and, in fact, not the germs or larvæ of hydatids? We have not the means of positively answering these queries. They involve difficulties which future naturalists may perhaps be enabled to clear up. The constancy, however, of the presence of the worms, and their numbers, in the turbid fluid, when the granules are either less numerous than

when the fluid is clear, or have altogether disappeared, lead us to infer that they spring from those egg-like bodies; and when we find thousands of perfect, but small hydatids, these worms being absent, we are induced to conclude that these are probably the worms in a stage of perfect development, structurally considered, and which, by their growth, would ultimately burst the parent cyst, and so escape. Let us, then, assume all this, (it is at least probable, if not proved,) and then endeavour, without having recourse to the unphilosophical theory of equivocal generation, to account for the presence of hydatids in the brain of the sheep or ox, or in any other inclosed portion of the animal system.

Let us conceive of an animal dying from the mischief caused by a hydatid in the brain, which hydatid is laden internally with myriads of granules, the presumed germs of perfect creatures. Now, it is granted that the parent entozoon perishes, but it does not follow that the granules or eggs which it contains also lose their vitality. In an animal so low in the scale of being, organically lower than even plants in general, and which is destitute not only of a distinguishable nervous system, but also of vessels of circulation, it is by no means going too far to consider the microscopic eggs as still retaining their vitality. But how long will they do so? Probably for many years. The seeds of plants have been known to retain their vitality for

many hundreds of years, and even more, and then to germinate under favourable circumstances, and so also may these granular germs of entozoa. After the death of their parent they may mingle with the atmosphere, or with the earth of the field; they may be absorbed by plants, and contained in their sap vessels, and during a thousand changes of situation remain torpid; but suppose them to be taken into the system of an animal—an animal weakly or inclined to disease, (for in such animals only do they become developed,) and what is the result? In what manner these eggs reach the situation in which their development may begin remains a mystery. Its development commencing, it increases yet more and more, reproduces in its turn myriads of granules, and perishes. Animal bodies, be it remembered, are not solid: they are not like iron, they are bundles of tubes; they are porous, the air permeates them, and they are ever changing their constituents.

But it may be asserted that as the eggs are so numerous, hydatids ought to be at least very common in healthy bodies. Not so; the vigorous circulation of the fluids in health, the rapid change of the constituent particles of the body, the oxygenation of the blood, may tend to prevent their development, while those ill understood conditions, which primarily constitute an unhealthy or debilitated system, that languid or feverish circulation, that loss of tone in the nervous and muscular

systems, that depressed condition in the organs of absorption and excretion, may favour their development.

Still, it may be said, what becomes of the myriads of eggs which never find such a favourable residence, and which never develop? do these perish? And if so, is not there an immense creation of vitality for no end? Is not the provision for life, as it respects these low beings, of which so few comparatively become matured, thrown, as it were, away? And may we not here, as in other departments of the animal kingdom, expect that the numerical ratio, the loss, and the reproduction of beings will be in accordance with each other? If it pleases the Creator thus to secure from annihilation these entozoa, why not? Who knows to what extent of destruction these granular ova are liable?

The plan may be, and we say is, one of perfect wisdom, and until we know every circumstance, we cannot in fairness ask such a question. Besides, we see the very same law as it respects the continuance of plants. The thistle perishes, but not until it has scattered thousands of its seeds around it, and given them to every breeze. Of these seeds all do not germinate; numbers are destroyed: they form the food of birds and various creatures, and it is in the multiplicity of them that the continuance of the plant as a species is secured. But it may be, that the egg of the hydatid, when not developed in an

animal body, becomes so under other circumstances, and presents such a modification of form and general appearance, as not to be then recognised; its growth and characters as a hydatid may depend entirely upon the supply of animalized food within its power of absorption; in the water it may be one of the myriads of strange animalcules of which we only know that "little is known." We do not say that this is the case, we merely suggest a possibility, perhaps even a probability; for the more we become acquainted with the lower orders of the animal creation, the more we are convinced that the laws applicable to the vertebrate classes, mammalia, birds, reptiles, and fishes, do not apply to them. Who would expect to find the gemmules of a sponge active locomotive beings, or to see the young of a barnacle swimming about? Let not the philosophic mind be startled, then, because difficulties are around us; nor run into theories bordering both on the absurd and the impious, because links in a chain of causes and effects are not obvious to our researches.

It has been asked, What objects are these hydatids accomplishing in their strange abode? We cannot tell, but we know that the same question is applicable to a great extent of animated nature. What object is accomplished by the existence of the animalcules revelling by thousands in a drop of water? What, by the multitudes of living things which the great sea contains? It is enough for us to know

that they exist, and that in wisdom they were created; and let us never forget that the counsel of God is beyond our finite comprehension. "Behold, thou hast made the heaven and the earth by thy great power and stretched-out arm, and there is nothing too hard for thee." So said one who had well considered the ways of God; but he who talks of matter spontaneously assuming vitality and definite organs, a specific form and texture, though he may by subterfuge ingeniously endeavour to extricate himself from the dilemma, virtually denies the necessity of a great, eternal, all-powerful Creator, by whom and in whom all things exist, and without whom "was not any thing made that was made."

If, in these observations, we have demonstrated something of the power of God, as displayed in the existence of beings little considered by persons in general, and involving much both wonderful and interesting; and if we have said anything, which, while it throws light, though but obscure, on the circumstances in which they present themselves to our notice, tends to convince the reader that the theory of equivocal or spontaneous generation is a baseless fabric, notwithstanding some philosophers are labouring to establish it, our object is accomplished.

There is a kindred theory, revived in a recent work, which has had a large circulation—a theory to which it will be well now to advert. It is thus stated: "The idea which I form of the progress of organic life upon our earth, and the hypo-

thesis is applicable to all similar theatres of vital being, is, that the simplest and most primitive type, under a law to which that of like productions is subordinate, gave birth to the type next above it; that this organ produced the next higher, and so on to the very highest, the stages of advance being in all cases very small, namely, from one species only to another; so that the phenomenon has always been of a simple and modest character."

This theory assumes that the monad we have already considered, the simplest form of animal life, was first created; that it gave birth to the next species of animalcules, and that onward this development proceeded, till the animalcule was lost in the mollusk, and the mollusk in the monkey, and the monkey in the man!

Now it ought to have been enough for the holders of this theory to have set themselves to answer the question, if such a power of development were possessed by cells, how has it become extinct? Innumerable facts attest that the monad produces only monads, and that throughout organic nature the germ is precisely like its parent. No species trespasses on the boundary line of another species. In its development, the Divine voice may be heard, saying: "Hitherto shalt thou come, but no further." And the declaration may not only be substantiated by the observations of every passing hour, but by an appeal to the testimony of every naturalist, from the earliest times to our own.

It has been judiciously said by Dr. Mantell, a diligent and persevering observer in an extensive field of organic nature, and one of the first philosophers who exposed the fallacy of this vaunted theory:—

"Although it is now a received physiological axiom, that cells are the elementary basis, the ultimate limit, of all animal and vegetable structures; and that the varied functions, in which organic life essentially consists, are performed by the agency of cells, which are not distinguishable from each other by any well-marked characters; there is not any ground for assuming any identity between the primary cells, even of the simplest species of animals or vegetables, much less between those of more complicated organization. The single cell which embodies vitality in the monad, or the yeast fungus, is governed by the same immutable organic laws which preside over the complicated machinery of man, and the other vertebrata; and the single cell which is the *embryotic condition* of the mammal has no more relation to the single cell which is the permanent condition of the monad, than has the perfect animal into which the mammalian cell becomes ultimately developed. The cell that forms the germ of each species of organism is endowed with special properties, which can result in nothing but the fabrication of that particular species. The serious error which pervades the theory advanced in the work entitled 'The Vestiges of the Natural

History of the Creation,' has arisen from its author having, in many instances, assumed *analogy* to be a proof of *identity*. There is an analogy between the human embryo and the monad of the volvox, in that each consists of simple cells; but there is no more *identity* between the human and the polygastrian cells than between the perfect man and the mature animalcule."

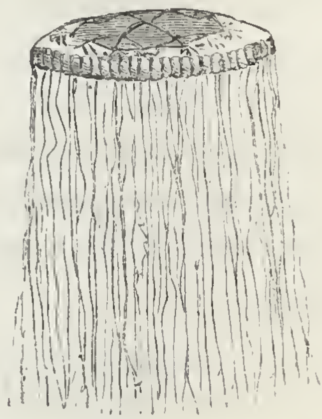
Nor is this all; the notion of "the stages of advance being in all cases very small," is as obviously false as every other part of the theory. The difference between the organization of reptiles and birds, and again of birds and mammals, is manifestly great; nor are there any other intermediate classes of organized beings to diminish, much less fill up, the vast hiatus. Incontrovertible facts declare, therefore, the utter fallacy of the pretence of a gradual development, and that the power does not exist, nor ever yet did, in which it has been supposed to begin.

"Proud, scornful man! thy soaring wing
Would hurry towards Infinity:
And yet the vilest, meanest thing
Is too sublime, too deep for thee;
And all thy vain imagining
Lost in the smallest speck we see.
It must be so:—for He, even He
Who worlds created, form'd the worm:
He pours the dew, who fill'd the sea;
Breathes from the flower, who rules the storm:
Him we may worship,—not conceive;
See not and hear not,—but adore."

CHAPTER XI.

THE SEA NETTLES.

The Medusa, or jelly-fish, so often observed on the sea-shore, is one of the *Acalephs*,* a name derived from the Greek word signifying a *nettle*, a class of beings placed by naturalists in the next rank to those which have just been considered. One is provided with long filaments, as represented in the engraving. Another creature has a central pedicle, descending from the lower surface, which hangs quite loose among the waves. Its surface is covered with pores, each one being the commencement of a fine canal, joining others, till at length large trunks are found, through which, whatever is imbibed by the root-like stem is poured into the central or digestive cavity. Other canals diverge from thence, run to the margin of the disc, and become a network of fine vessels, conveying nutriment throughout the body. It might be supposed that such a creature—a living jelly, was ill fitted to prey on other animals. But,



CUVIERIA CARIOSCHROMA

* Acalephæ.

in common with the class to which it belongs, God has endowed it with a stinging power, which is equal to all its necessities. No sooner does a fish come in contact with this apparently helpless creature, than the medusa emits a fluid so pungent that the victim is paralyzed and motionless, and becomes an easy prey: this power, however, does not appear to be possessed by all the species.

The medusa may be seen to depress the margin of its body, and to flap with its fringed membrane, somewhat like the opening and shutting of a parasol, thus exerting its power of locomotion. The movement referred to is performed about fifteen times a minute, very regularly; and by the reaction of the water, the medusa is sustained at the surface. It descends in the water by simply contracting its substance in all directions; and sometimes, to sink more quickly, it turns itself over, so that the convex part is uppermost.

In some species, the young may be observed, at a certain period, transferred from the ovaries on the lower surface of the body. After changing in size, colour, and form, they are clothed with cilia, and then swim freely about. On one of them adhering to some object covered with cilia, arms appear about the mouth, and actively seek the needed food. It now freely swims about till winter comes, when it continues in quietude. At the approach of spring, transverse lines appear on the surface; these deepen into furrows, dividing the body into several

portions, which, for a time, remain in contact, but subsequently each part swims about, until the last change takes place, and mature medusæ appear.

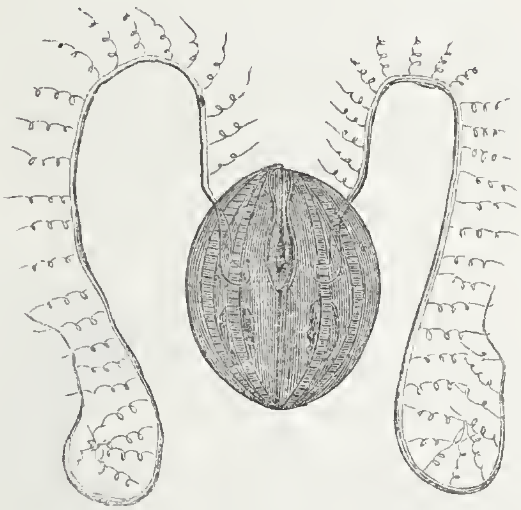
"We see," says professor Owen, "that a medusa may actually be generated three successive times, and by as many distinct modes of generation—by fertile ova, by gemmation, and by spontaneous *fission*—before attaining its mature condition."

And yet what is the actual substance of a creature endowed with all these powers? Were the reader, on his next visit to the coast, to take with him one weighing five or six pounds, in a vessel, and to set it aside, what would he discover when a few hours had elapsed? The animal he deposited in the vessel? Certainly not. All the solid matter left is a membranous cellular film, weighing only a few grains, and the fluid drained away is not to be distinguished, by the most accomplished chemist, from common sea-water. And yet, when these were combined, and instinct with the mysterious power of life, there was the medusa, bearing its simple but conclusive testimony to the perfections of the Infinite!

Other creatures may be described as transparent bodies, differing in size, but, in general, about as large as a boy's marble. Externally they exhibit ridges like those of a melon, and are in form not unlike an orange or an apple, from which circumstance they take their specific name.* They move by means of vibratile cilia, which extend from the

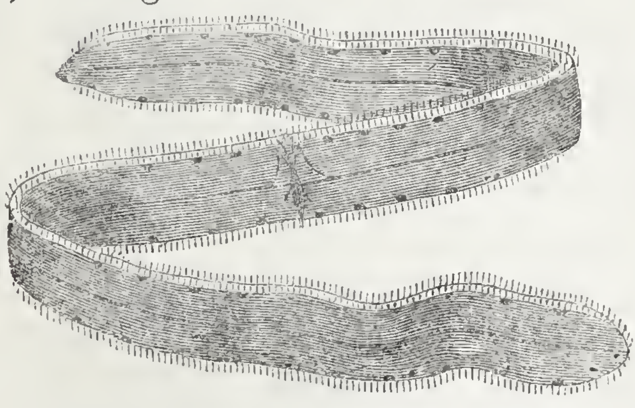
* Cydippe pomiformis.

upper to the lower extremity of the body. They can rise or fall at pleasure, executing, as they move up and down, with rapidity and ease, a marvellous series of evolutions.



THE CYDIPPE, OR BEROE.

Greatly differing in external appearance from the animal last described, though allied to it in certain respects, is the girdle of Venus. This creature, an



THE GIRDLE OF VENUS.—CESTUM VENERIS.

inhabitant of the Mediterranean, appears at first, to be a long flat riband of translucent glass; its

length is sometimes six or seven feet, its breadth only three or four inches, and its substance extremely delicate. The countless cilia, placed on the margins of its body, are its oars, which move it in graceful undulations through the tranquil waters. They serve also to bring food to the mouth—a small orifice placed on the upper margin, near the middle of the body; and the digested nutriment is conveyed through long canals to the remotest part of the animal.

Far more frequently is the *Physalus* found, called by seamen the Portuguese man-of-war. Its body consists of a large pear-shaped vesicle, containing air, which floats upon the water; and from the lower portion descend a variety of organs to hold prey, to suck nutriment, and to bear eggs. From the upper part rises a beautiful purple sail, which bears the physalus onwards alone, or in company with a fleet of its kind. Wishing to sink beneath the waves, or sensible of danger, it forces the air through orifices provided for its escape, and again, at its pleasure, becomes full of this fluid, that it may float on the bosom of the sea.


PORTUGUESE MAN-OF-WAR. —THE PHYSALUS.

Some hues of the ocean are traceable to animalcules. Dr. Pöppig, in his "Voyage to Chili," says, "From the topmast the sea appeared, as far as the eye could reach, of a dark red colour, and this in a streak the breadth of which was estimated at six English miles. As we sailed slowly along, we found that the colour changed into brilliant purple, so that even the foam, which is seen at the stern of a ship under sail, was of a rose colour. The sight was very striking, because this purple streak was marked by a very distinct line from the blue waters of the sea, a circumstance which we the more easily observed, because our course lay directly through the midst of this streak, which extended from south-east to north-west. The water, taken up in a bucket, appeared indeed quite transparent, but a faint purple tinge was perceptible when a few drops were placed upon a piece of white china, and moved rapidly backwards and forwards in the sunshine. A moderate magnifying glass showed these little red dots, which only with great attention could be discerned with the naked eye, consisting of infusoria, which were of a spherical form, entirely destitute of all external organs of motion. . . . .We sailed for four hours at a mean rate of six English miles an hour, through this streak, which was seven miles broad, before we reached the end of it; and its superficies must therefore have been about a hundred and sixty-eight English square miles. If we add that these animals may have been equally distri-

buted in the upper stratum of water, to the depth of six feet, we must confess that their numbers infinitely surpassed the conception of the human understanding."

Another remarkable fact in connexion with the ocean has been thus referred to by Coleridge:—

"Beyond the shadow of the ship,
I watch'd the water-snakes:
They moved in tracks of shining white,
And when they rear'd, the elfish light
Fell off in hoary flakes.

"Within the shadow of the ship
I watch'd their rich attire:
Blue, glossy green, and velvet black;
They coil'd and swam, and every track
Was a flash of golden fire.

"O happy living things! no tongue
Their beauty might declare:
A spring of love gush'd from my heart
And I bless'd them unaware."

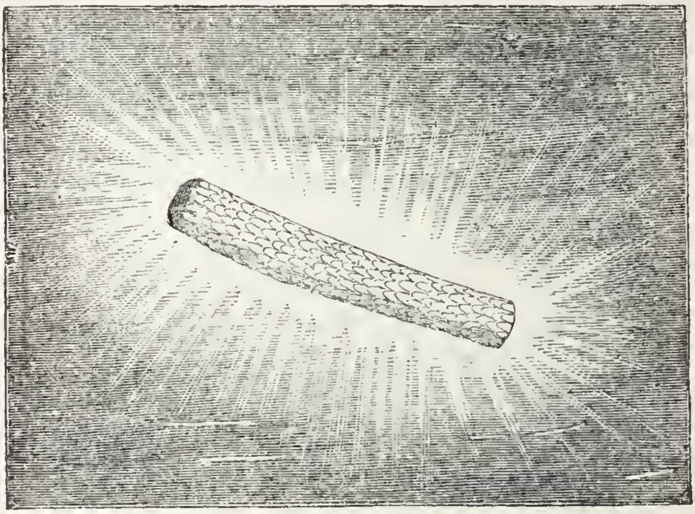
The phosphorescence of the sea exhibits the greatest brilliancy between the tropics. Sometimes the vessel, while ploughing her way through the billows, appears to mark out a furrow of fire; each stroke of the oar gives rise to sparks of light, sometimes brilliant and dazzling, at others tranquil and pearly. These movable lights, too, are grouped in endless varieties; and their thousands of luminous points, like little stars, appear floating on the surface; and then, crowding together, form one vast sheet of light. Then the scene becomes more

tumultuous; the bright waves heave up, roll, and break in shining foam. At other times, large sparkling bodies, resembling the forms of fishes, pursue each other, disappearing and bursting forth anew.

In some cases, the luminosity of the ocean is owing to the sea-nettles, which are scarcely perceptible without the assistance of a microscope. All, however, are not equally minute; the cydippes, in which the cilia would seem to be most vividly phosphorescent, are of considerable size; the girdle of Venus, as it glides rapidly along, has the appearance of an undulating riband of flame, several feet in length; and many larger creatures shine with such dazzling brightness, that they have been described by navigators as resembling "white hot shot, visible at some depth beneath the surface."

Among luminous beings the *Pyrosoma* holds a prominent place. Mr. Bennett, in one of his voyages, observed the sea presenting one mass of phosphoric light, extending to a considerable distance around the vessel. So powerful was it as to illuminate the sails, and to permit a book of small print to be read with facility near the windows of the stern cabins. Above this bright field, numerous sea-fowl were hovering in search of their prey. The light appeared to be entirely owing to the *Pyrosomata*. Specimens taken from the sea and placed in a vessel containing sea-water, ceased altogether to emit light,

or emitted it but sparingly while they remained at rest. On the water, however, being agitated, or when one of the masses of animals was taken into the hand, the whole became instantly illuminated



THE PYROSOMA.

by myriads of bright dots, much resembling in hue the points on the elytra of a diamond beetle.*

The mass of these animals, of the usual cylindrical form and gelatinous substance, was about four inches in length and one and a half in circumference. Each tube is described as being open at both ends; the orifice at the broader extremity being much better defined in its circular form, larger and more distinct than that of the opposite end. The surface of the mass appeared to be studded with numerous prominent, rigid, and pearly tubercles, intermingled with small specks of brown

* Circulio imperialis, *Fab.*

or red colour. In these latter, the power of emitting light appeared chiefly to be seated; these being frequently bright, while the remainder of the body exhibited only its natural white or yellowish white hue; a hue which changed after death into a red tinge. The brown specks, when removed from the body, did not emit light.

But what, it might be asked, is the great design of this phosphorescence? And assuredly, much might be said in reply to this question, beyond our present limits. Let it however be observed, that light diminishes rapidly in passing through water, and that absolute darkness reigns in the depths of the sea. And yet it teems with active and rapacious beings: often social, performing various functions, moving hither and thither with the celerity of birds, and above all, provided in countless instances with visual organs. How then are they to see in a world of gloom?

Infinite Wisdom has solved the problem, by establishing an independent source of light beneath the ocean, and so precisely disposing it, as effectually to answer the intended purpose. That the animal may be seen in utter darkness, it is rendered luminous; and this provision was necessary for the pursuit of food. But for this, the deep-residing fishes could not have found the means of subsistence, and the night-preying ones would have been utterly helpless. Now, there is an abundant and accessible provision for all.

It is also worthy of remark, that while the light of living marine animals is commonly confined to a certain portion or organ, the whole body shortly after death becomes luminous, emitting a pale uniform light. The luminous matter may now be detached and diffused through water—a fact familiar in our larders, while there can be no such separation of the living light. Not as is commonly supposed, that the luminous appearance of fish is a result of putrefaction; it commences long before this process, and ceases when it is established. The design of this arrangement is as obvious as that just mentioned: the dead creature is still food; by putrefaction it would be wasted, and might be injurious; but it becomes an object of attraction under this new expedient, as it had ceased to be, in losing with its vitality its former power of producing light.

Such arrangements are not limited to marine animals having eyes. These organs are now known to exist in multitudes which were long supposed to have no such power. The microscope has placed the fact beyond all doubt. But even where they are assuredly wanting, as in the medusæ and the beroes, there is a perfect sense of a luminous object when present: they will pursue a moving candle with the accuracy of a fish, and eagerly crowd round the single opening for the admission of light which has been left in a darkened vessel.

CHAPTER XII.

THE WHEEL-BEARING ANIMALCULES.

We have now to consider another class of animalcules. The *Rotifera*, or wheel-bearers, are proved, by the recent discoveries of the microscope, to be distinguished from the *polygastrica* by many important differences of organization. They belong to that division of the animal kingdom, termed, by professor Owen, *Nematoneura*, from two Greek words, meaning a thread and a nerve, from the circumstance that it is here that the first traces of distinct nerves, in the form of fine threads, begin to make their appearance, and in some instances, ganglia, or rudimentary nervous centres. In addition to this character, distinct muscular fibres are perceptible, arranged in bundles; and though there is no heart or great receptacle for the circulating fluid, there is a system of vessels for its due distribution through the frame. The digestive apparatus also assumes a more perfect state, and instead of consisting of mere cavities in the substance of the body itself, it presents a true stomach and intestinal canal, with various appendages. The mode of reproduction is no longer by the division of the parent or adult into new beings, but by eggs, containing the vitalized germ of the future animals.

But though the first traces of distinct nerves are

manifest, it is to be observed, that these nerves are not always capable of being demonstrated. In some groups they elude our research, perhaps from their extreme delicacy; in other groups, as the *rotifera*, the minuteness of the animals themselves renders the detection of such organs almost hopeless. And, although Ehrenberg considers that he has succeeded in discovering, not only nervous filaments, but even nervous ganglia, there is, perhaps, reason to suspect that he may have been misled by appearances. We do not mean to say that nerves do not exist in these animalcules, for many things render it most probable; but merely, that it yet remains to be demonstrated that the filaments described by him are nerves.

The wheel-bearing animalcules are so termed, from the appearance of certain wheels near the mouth, described by the earlier microscopic observers, who seeing them rotate with great velocity, were completely at a loss to know how to account for their presence and motion, or to conceive of the nature of their organic union with the body of the animal itself. But this rotation is an optical illusion; it is now proved that there are really no wheels at all, and that the appearance of them arises from circlets of minute cilia, while the apparently rotatory motion in question is produced by a series of progressive undulations, in consequence of the alternate and orderly extension and contraction of each separate fibril.

According to the observations of Dr. A Farre, the cilia, under a microscope of high powers, present an appearance of waves rolling round and round in a circle; each wave is produced by a number of cilia, those forming the highest point being at full stretch; the others folded down upon themselves in an increasing ratio to the middle of the interval between two waves, where they are most completely lowered: these, however, become in turn the most elevated, and those which were the highest, the most lowered, and so on in alternate succession, and with great rapidity, the waves appearing to roll onwards.

The cilia are certainly endowed with voluntary motion; they are regulated in their actions by the will of the animal; they can be urged into movements of extreme rapidity, put into gentle and tranquil action, or stopped in an instant. Sometimes, a portion only of the circlet of cilia is in action, while the other portion is quiescent; and sometimes a few cilia alone are seen slowly bending, and then stretching themselves; when all at once the whole begin to work with the utmost energy, wave succeeding wave with wonderful velocity. It is by the action of these cilia, that the animalcule rows itself through the water, and traverses the tiny ocean in which it revels, full of animation. They are not, however, exclusively organs of locomotion; they serve for the acquisition of food. Fixing itself by means of a pair of forceps, ter-

minating the body, to some stationary object, (as, for example, an aquatic plant,) the animalcule sets its cilia in action, and thereby produces a rapid current in the contiguous water, converging to the creature's mouth, and hurrying thither such minute particles, either of an animal or vegetable nature, as are drawn into the mimic Charybdis. It appears that the cilia of these animalcules, whatever their own structure may be, are governed by a muscular apparatus, which is very conspicuous, and which retracts them, when not in use, within a kind of sheath, where they are safely lodged till their action is required.

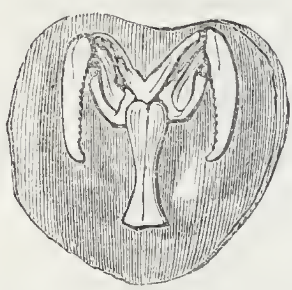
The *rotifera* may be described as shell-covered animalcules, their body being inclosed in a moderately firm or horny investment, but of extreme delicacy and very transparent, so that the internal viscera may be perceived through it. The upper, or free margin of this shell, is often indented, or ornamented with regular projections, and is continued by means of a fine membrane to the bases of certain elevations around the mouth, termed lobes, from which arise the cilia already described. This membranous continuation of the shell does not confine the ciliary apparatus, but permits it to be retracted at pleasure within the shell.

These creatures present great variations of form and colour; but all have at the posterior extremity of the body a pair of forceps or pincers, instruments of prehension, by which they attach themselves at

will to stationary objects: in some, these pincers terminate a long muscular tail-like appendage; but in others, the pincers terminate a mere projection. The mouth leads into a gullet, which varies remarkably in size in different species: in some it is very capacious; but in others it is a narrow canal. The gullet leads to a gizzard, or preparatory receptacle, in which, by means of a curious apparatus, the food is either ground to pulp, or cut into fragments.

PINCERS OF AN ANIMALCULE.

This apparatus is described by Ehrenberg as consisting of three teeth, which, by the action of the gizzard and of certain muscles belonging to them, work vigorously on each other, and so mince to pieces whatever is subjected to their operation. These teeth are three in number, as in the sketch, and consist of one central and two lateral or superior ones: the central tooth is apparently fixed, and has two flattened facets on its upper surface, one for each superior tooth to work upon. Each of these superior teeth consists of two portions, namely, a basal portion, fixed to the walls of the gizzard, and serving for the attachment of muscular fibres; and a free movable portion, which may be regarded as



GIZZARD OF AN ANIMALCULE.

the real tooth, while the other serves as a jaw. These three portions work with their inner edge upon the facets of the central piece, and this edge appears to be jagged or serrated, the better to tear the substances on which it acts. Minute as are these curious organs, the transparency of the *rotifera* permits them to be distinctly seen, under a powerful microscope, which also demonstrates their effects upon the bodies of the smaller animalcules on which the various species prey; for, as with fishes, they are the food of each other, and the warfare is perpetually carried on. The hardness of these teeth is not a little surprising; they may be detached from the body of the animalcule in a perfect condition, and be submitted by themselves to examination beneath a microscope; they vary in minor particulars, as form and size, in every species; but their essential characters appear to be the same in all.

From this teeth-furnished gizzard, or preparatory receptacle, a passage varying in length in different animalcules, leads to the true stomach, or digesting cavity, to which the food, after being subdivided, is conveyed. The form and the relative capacity of the stomach, like those of the gizzard, are very variable; but in all these rotiferous animalcules this part is furnished with certain appendages, which are regarded as being of a glandular structure, and destined to secrete a fluid essential to the performance of digestion.

The *rotifera* are oviparous; they produce eggs, from which the young are excluded, sometimes while yet within the body of the parent. The eggs of some of these animalcules, appearing like minute transparent globules, are calculated to be, when first deposited, only the twelve thousandth part of an inch in diameter; but they increase in magnitude, and then constitute most interesting objects of microscopic examination. In an egg of about the one thousand and seven hundredth part of an inch in diameter, the included animalcule may be distinctly perceived, even the actions of the cilia may be distinguished, producing the wheel-like rotatory appearance previously described. At certain times, the eggs may be easily recognised before being deposited by the animalcule, lodged in a long floating sac, in the cavity of the body; for the transparency of the creature is such as to permit the minutest parts of its internal structure to be seen; but it often happens that the sac is empty.

Such, then, is the general outline of what we know of the structure of the rotifera. They are active and vivacious creatures, and by the celerity and address of their movements, give delight to those who observe them. To see a shoal of them in a drop of water, avoiding each other in their mazy courses, and performing a thousand mingled evolutions, is perhaps one of the most interesting spectacles which the reflective can contemplate; but this delight gives way to astonishment, or

rather to meditation, when he perceives that these creatures are elaborately constructed; that they are organized with an express relationship to their destined mode of life; and that they enjoy their existence like the fishes of the sea, the birds of the air, or the wild beasts of the desert.

It has already been stated, that oxygen is the great supporter of animal life, and consequently every living creature is incessantly engaged in converting it into carbonic acid by the process of respiration. It is estimated that one man daily changes no fewer than 18,000 cubic inches of the oxygen of the air into carbonic acid, by the carbon discharged from the lungs, and consequently, the amount changed by the whole animated population of the globe must be enormous. Other demands are made on this essential element of life, as the oxygen of the atmosphere is indispensable to combustion. It has been calculated that the small town of Giessen. in Germany, with a population of 7,000 inhabitants, yearly changes more than 1,000,000,000 cubic feet of oxygen into carbonic acid, by the combustion of wood as fuel; and Dr. Carpenter says, in an English manufacturing town, where the proportion of coal used is far greater, the amount would be at least twice as much in proportion to its size. Now, empty jars buried in the city of Pompeii, when it suffered this catastrophe from an eruption of Vesuvius 1,800 years ago, demonstrate that no change has taken place in the proportion of the

gases which constitute the atmosphere. We find them in fact always and everywhere the same. Infinite Wisdom has provided, therefore, that as there is an enormous demand on one of its elements, so of this there should be as ample a supply.

In a very interesting memoir by Messrs. August and Morren, contained in the Transactions of the Academy of Brussels for 1841, it is shown that water with organic substances evolves a gas which contains sixty-one per cent. of oxygen; and they conclude their treatise by saying: "It follows from the preceding remarks, that the phenomenon of the evolution of oxygen gas is due to the *Chlamidonomas pulvisculus*, Ehrenberg, and to several green animals still lower in the scale."

In Liebig's Chemistry, this statement is quoted, and that eminent man then proceeds to remark: "The author took the opportunity of convincing himself of the accuracy of this long-observed fact, by means of some water out of a trough in his garden, the water being coloured strongly green by different kinds of infusoria. This water was freed, by means of a sieve, from all particles of vegetable matter, and being placed in a jar inverted in a porcelain vessel containing the same water, was exposed for several weeks to the action of solar light. During this time a continued accumulation of gas took place in the upper part of this jar. After fourteen days, one-third of the water in the jar had been pressed out of it, and the gas which had taken its

place ignited a glowing mass of wood, and in all respects behaved like pure oxygen gas."

Here we pause in our study of organic beings, on whose structure so much light has been thrown by the use of the microscope. Well was it said by Dr. Chalmers, as he viewed the telescope in comparison with that instrument: "The one led me to see a system in every star; the other leads me to see a world in every atom. The one taught me that this mighty globe, with the whole burden of its people and of its countries, is but a grain of sand on the high field of immensity. The other teaches me, that every grain of sand may harbour within it the tribes and the families of a busy population. The one told me of the insignificance of the world I tread upon. The other redeems it from all its insignificance; for it tells me that in the leaves of every forest, and in the flowers of every garden, and in the waters of every rivulet, there are worlds teeming with life, and numberless as are the glories of the firmament. The one has suggested to me that, beyond and above all that is visible to man, there may lie fields of creation which sweep immeasurably along, and carry the impress of the Almighty's hand to the remotest scenes of the universe. The other suggests to me that, within and beyond all that minuteness which the aided eye of man has been able to explore, there may be a region of invisibles; and that, could we draw aside the mysterious curtain which shrouds it from our senses,

we might there see a theatre of as many wonders as astronomy has unfolded, a universe within the compass of a point so small, as to elude all the powers of the microscope, but where the wonder-working God finds room for the exercise of all his attributes, where he can raise another mechanism of worlds, and fill and animate them all with the evidences of his glory."

Still, whatever additions may yet be made to human knowledge,—and we will hail them all with gratitude and delight,—the voice of nature can never relieve the solicitude of man, conscious of guilt and that he is endowed with endless life. Divine revelation alone reveals the only ground of acceptance before God, in the mediation of his only-begotten Son; the only means of acceptance, in faith in his equality with the Father, his atoning blood, and perfect righteousness; and the only evidence of acceptance, in holiness of heart and life.

We would have all diligent and persevering students, according to their means and opportunities, of the natural world. But it is possible to connect the Supreme with his works, without receiving the truth that "God was in Christ, reconciling the world unto himself, not imputing their trespasses unto them," and consequently without obeying the charge, "Be ye reconciled to God." Compared with embracing "the faithful saying," which is "worthy of all acceptation, that Christ Jesus came into the world to save sinners," all

other knowledge is passing and worthless. For the knowledge that is "life eternal," all other attainments should be accounted "dross."

Happily both have been and are still combined. To take only one example: Did the religion of Dr. Turner* impede his exertions in the field of philosophy; or in any way depreciate their value? The testimony of his friend, the rev. T. Dale, should be inscribed upon the heart of every man of science. "He received the Bible with implicit deference, 'not as the word of men, but as it is in truth, the word of God.' Blameless, excellent as he was, to outward appearance, in every relation of life, he knew that he could not abide the scrutiny of One who looked upon the heart; and he joyfully took refuge in the comfortable doctrine of an Almighty Saviour, one 'able to save them to the uttermost that come unto God by him.' When Dr. Turner knew that death was near, he adverted to the calmness of his pulse, and asked, 'What can make it so at such an hour? What but the power of religion? who but the Spirit of God? I could not have believed,' (he said,) 'that I could be happy on my death-bed. I am content my career should close.' The question was put to him, 'Is not Christ as good as his word?' 'Yes,' he faltered, 'quite.' And when he had said these words, he fell asleep."

* The laborious Secretary of the Geological Society.

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